Employment and Immigration Canada
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Canadian Shipbuilding and Ship Repairing Association

Opportunities in Shipbuilding

Canada

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Opportunities in Shipbuilding

An introduction to the shipbuilding, ship repairing and allied industries and a guide to the education and training of personnel.

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A Message from the Minister of Employment and Immigration

For many years, the Canadian Shipbuilding and Ship Repairing Association and Employment and Immigration Canada have worked closely together to plan and manage the human resource needs of this important industry. Foremost has been our desire to ensure that Canadians have access to the career opportunities which are opening up in shipbuilding and ship repairing.

The Canadian Shipbuilding and Ship Repairing Association has continued to develop innovative strategies to inform Cnaadians about the potential for challenging jobs in the industry. Employment and Immigration Canada has been pleased to be able to apply its programs and services to assist in implementing those strategies. *Opportunities in Shipbuilding* is an outstanding example of the positive benefits which result from such cooperation.

This is one of many publications produced by Canada Employment and Immigration Commission designed to assist people who need career counselling, who are making decisions, changing careers, or seeking employment.

The publishing of this book exemplifies our continuing endeavours to foster joint collaboration between industry and the Government of Canada. I look to *Opportunities in Shipbuilding* as a valuable resource document for all.

John Roberts

Foreword

The building of ships is one of Canada's oldest industries. History records that the first vessels built in New France were two small craft launched at Port Royal (now Annapolis Royal in Nova Scotia) by François Grave in the year 1606. In Quebec, a sea-going vessel named the Galiote was built in 1663. Several others followed and in 1672 a ship of 400 tons burden (a large vessel for the period) was built at Anse des Meres, Quebec. For the next half century sailing ships, fit for the Atlantic crossings, were constructed in Quebec but shipbuilding was not recognized as a commercial industry until Intendant Hocquart established a shipyard on the banks of the St. Charles River, Quebec and built ten merchant vessels there in 1732.

As the century progressed, Canadians of French and British origin embarked in the business of shipbuilding in earnest to exploit the enormous timber resources of the colony. Soon a thriving industry was established which rivalled that of Europe in the creation of large, swift and seaworthy vessels.

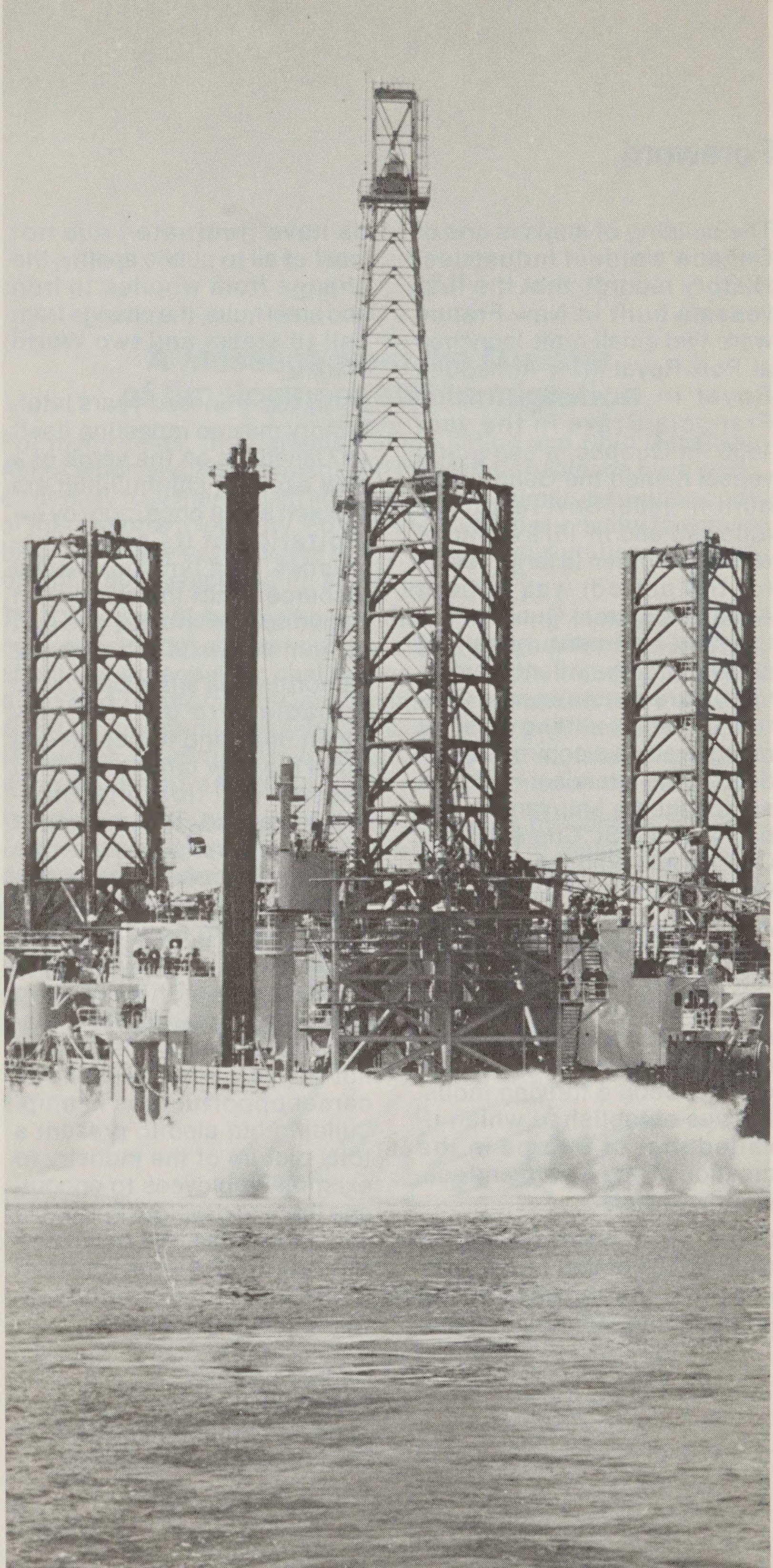
From that heyday of the Golden Age of Sail to the present time, the fortunes of the shipbuilding industry in Canada have fluctuated due not least of all to public apathy, the change from wooden to iron and steel hulls, the change from sail to steam and two World Wars.

Now, two hundred years later, history may be repeating itself as Canada is on the verge of a new exciting shipbuilding era brought about once more by exploitation of its natural resources. This time the natural resource is not the wood from Canadian forests but gas and oil from the Arctic and offshore.

Opportunities again beckon to Canadians to develop new technology and to design and build the new unique types of vessels and floating equipments needed. The immediate and long term future for the Canadian shipbuilding industry and for the supporting industries has never looked brighter.

The Canadian Shipbuilding and Ship Repairing Association has prepared this booklet not only to inform the public on career opportunities in shipbuilding but also to present a total picture of the industry to existing employees to encourage them to develop their skills and knowledge. We thank Employment and Immigration Canada for their support towards this publication.

Henry M. Walsh
President
Canadian Shipbuilding and
Ship Repairing Association



Launching of a Jack-up Drill Rig

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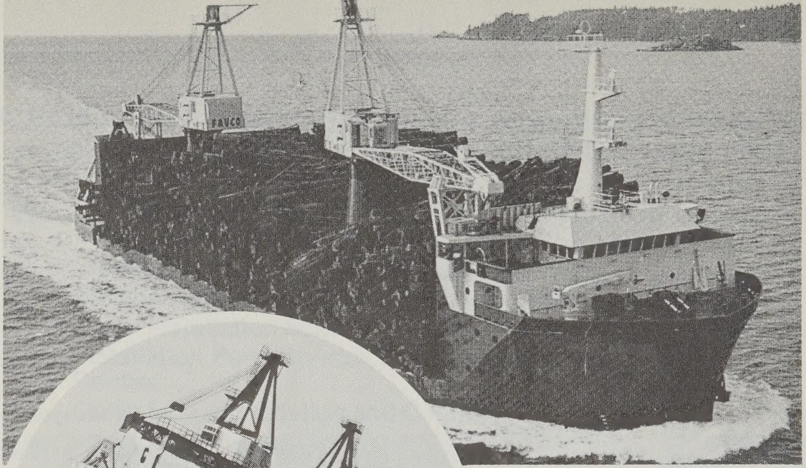
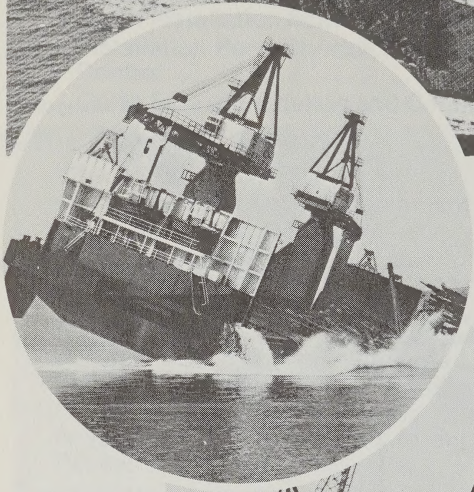
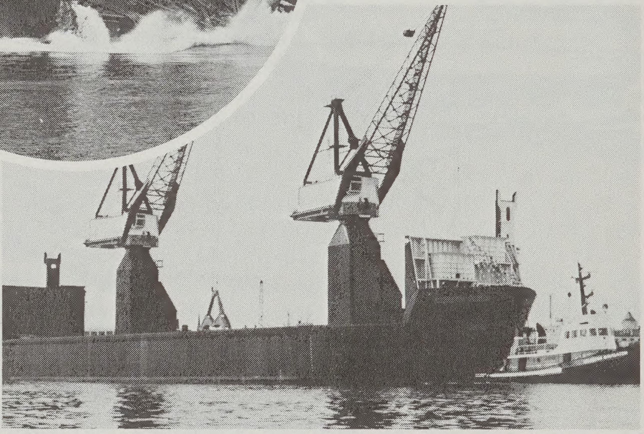
Shipyard with Graving Dock





Huge Self-Loading,
Self-Dumping Log Carrier



Fabricating a Vessel

Introduction

Shipbuilding calls for a vast variety of skills which include ship design; marine, mechanical, electrical, electronic and oceanographic engineering; scientific research and development; human engineering; instrumentation; computer programming and operation; accountancy; drafting; quality assurance; steel fabrication; welding; engine fitting; carpentry/joinery; pipe fitting; painting; rigging/slinging and crane operation.

Shipyards are continually changing as new technology and advanced types of vessels are developed. To be competitive, shipyards seek to improve productivity through modernization of their yards and equipments and by introducing new and improved methods of production.

With the anticipated early exploitation of Canadian resources in the Arctic and offshore and the associated enormous need for new and unique vessels and floating equipments, the Canadian shipbuilding industry is on the move to better times. Not only should shipbuilding be a very high growth industry but this level of activity should be sustained for decades to come. Moreover, the increased demand for components and material from the support industries will result in increased productivity through economies of scale and the establishment of new support industries leading to new export opportunities.

In the pages which follow, a description is given of the variety of vessels being built today and those on the drawing boards for the future, followed by an outline of a typical progressive Canadian shipyard. Following a brief outline of how a shipyard builds a ship, the various careers available in the industry are identified and explained.

Inserting an extra car deck in a Car-Passenger Ferry

Shipyard with Floating Drydocks

CHAPTER 1

MARINE TRANSPORTATION & OFFSHORE EXPLOITATION

The Outlook

The capacity of marine transportation worldwide more than tripled between the years 1960-1979. During the same period the cargo carried increased from 1,080 million metric tons in 1960 to 3,754 million in 1979. There is no doubt that it will continue to grow as the world's population and standards of living increase. Moreover, its growth will be assured as relatively unexplored parts of the world such as the Arctic are developed and exploited.

Sea transportation of all but the most expensive cargos is the most economical. At 1982 energy prices, one gallon (Imperial) of fuel will ship 600 ton-miles of bulk cargo by water which is about three times as efficient as rail transport, more than eight times as efficient as road transport, and 150 times more efficient than air transport. Thus, it is understandable why international trade is primarily (about 70-75% by volume) carried out by ships and why in the face of rising energy costs the sea mode will continue to be predominant.

To provide the ships and the various other vessels and floating equipments needed for marine transportation, for Government, for the fishing industry and for the exploration and exploitation of natural resources from the Arctic and continental shelf, an efficient shipbuilding industry in Canada must exist backed by competent Canadian supporting industries. The Gross Registered Tonnage (GRT) of Canadian flag ships in 1982 exceeded 2 million tons. This tonnage which represents the Great Lakes fleet provides the most economical form of transportation for our national resources in the region. The shipbuilding industry which produced much of this tonnage together with the ship repairing and supporting industries currently employ over 20,000 people, mostly in the skilled category.

Over the past ten years, productivity in the Canadian shipbuilding industry has increased dramatically through the modernization of yards, introduction of innovative ship designs and new production tech-

FIG. 1

CANADA

(Excluding Far North)

● Principal Cities

★ Shipbuilding and Repair Centres

Vessel converted for seismic research

niques. Larger and more complex vessels than ever before are being built and new unique types of vessels and floating equipments for use in the Arctic and in the offshore ice-infested waters are being designed and developed.

To meet the anticipated great demand for new vessels and other waterborne equipments a number of the shipyards in Canada are expanding and/or increasing their capacity for new construction and ship repair. There is a possibility that a new world-scale shipyard will be built, in addition to a large steel fabrication yard. With these additions, not only will the building of all types of vessels envisaged be possible, but the capacity should be such as to enable the Canadian industry to meet most of the projected needs during this decade and for decades to come. With the design and construction of the highly specialized and unique Arctic and offshore equipments by Canadians, Canada will continue to be the leader in Arctic marine technology and thus have a potentially valuable asset for export. This will help to sustain and increase our national prosperity.

With the increased demand, the supply of material and equipment from the domestic supporting industries, much of which heretofore was uneconomical for production, should be predominantly Canadian. The increase in the building of ships together with the increased demand for material and equipment from Canadian producers, will be a most important source of employment, both directly and indirectly, to large numbers of people in all regions of Canada. Indeed, the livelihood and well-being of thousands of Canadians, whether employed by the suppliers of basic materials or by the sub-contractors, is linked with the Canadian shipbuilders.

A map of Canada which shows the principal shipbuilding and ship repair yards is given in Figure 1.

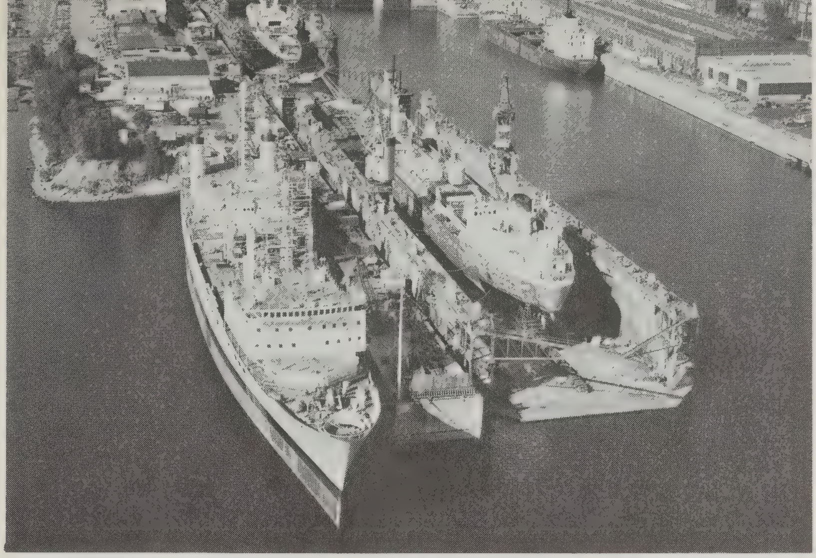
Shipyard with huge Floating Drydock in foreground

The Domestic Shipbuilding Market

For shipbuilders to be able to construct the right types of vessels at the right time at the right prices in our free market system, they must study the trends developing in world trade and in any sector in which they wish to compete. This involves a great deal of research covering economic, geographic and product development studies as well as the possible development of new technology to ensure that for a specific product the unit cost of its transport is minimised. For example, if the product is oil from the Arctic, the creation of the optimum design of the Arctic carriers let alone their construction is most complex and hence costly. Therefore, to minimize the cost of the transport of oil, series production in Canada of the Arctic oil carriers would be advantageous.

The trade in raw materials, energy and manufactured products on the Great Lakes and in the St. Lawrence Seaway, has led to the development of specific vessel types. In addition, on the East and West Coasts, on lakes and inland waterways there are the inshore and offshore fishing fleets, tugs and barges of most types and many other vessels.

Significant in recent years has been the rapid emergence of special vessels and floating equipments, for use in the Arctic and offshore in the exploration and exploitation of petroleum and mineral natural resources. In addition, there is a need for submersibles for exploitation of natural resources from the sea-bed, warships for defence, icebreakers for the Arctic and Seaway, other vessels for regulatory and safety-at-sea tasks, special vessels for oceanographic research and for search and rescue, passenger and car ferries for trade and tourist traffic, and small craft for recreation.



Vessels under repair

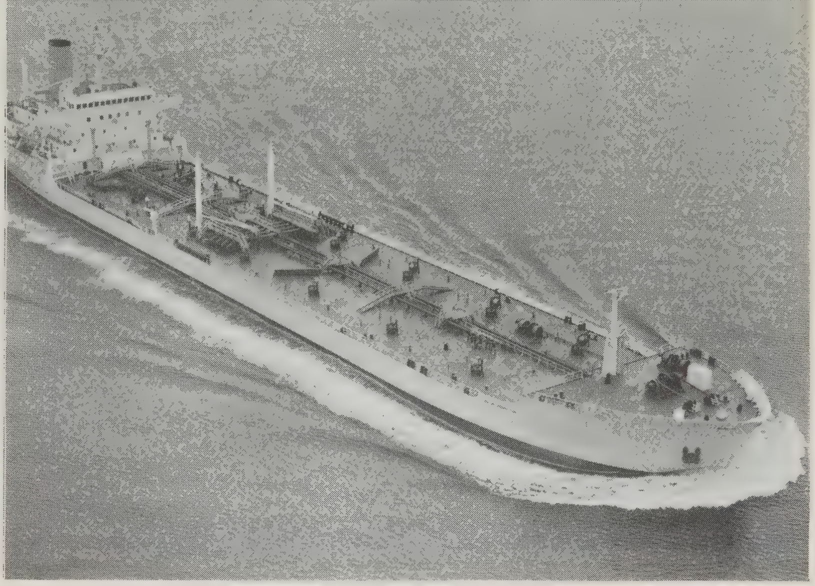
Ship Repair and Conversion

As a major trading nation, Canada must have adequate ship repair facilities. Usually, adjacent to its major ports, these facilities are also involved in new construction to provide a measure of stability for the maintenance of an adequate pool of skilled tradesmen. In recent years, ship repairs and conversions, have accounted for about a third of the industry's productive output in dollar terms.

However, during the same period a considerable amount of foreign flag work has been lost because of inadequate dry docking capacity. Dry docks enable ships to be taken out of the water and work to be performed on their underwater parts. The configuration of modern dry docks reflects the changing shape and size of ships now plying the oceans of the world. In the 1950's it was common for deep-sea vessels to have a capacity of 10-15,000 deadweight tons, whereas now it is more usual to see ships of 40-50,000 DWT, with some of the larger exceeding 50,000 DWT.

In some areas of the country adequate capacity has not been available to handle the larger and increased number of vessels. This deficiency is being corrected on both coasts with a major new Panamax size dry dock on the West Coast, new dry docks under construction for St. John's, Newfoundland and Halifax, Nova Scotia and a major expansion of the dry dock in Saint John, New Brunswick. Smaller dry docks have also been completed in recent years on both coasts.

In 1981, ship repair and conversion work worth $300,000,000 was carried out by CSSRA shipyards. With the new facilities, a substantial increase in future years is anticipated.



38,000 DWT Oil Carrier

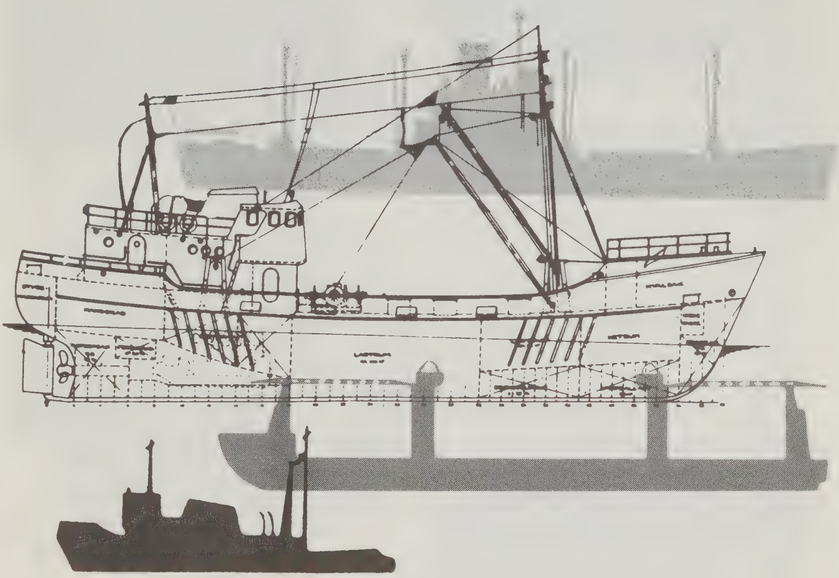
Other Industrial Activity

Shipyards, with their machine, electrical, steel preparation and fabrication shops have extensive capabilities for industrial work outside their primary role. In Canada, this work has been mainly in the heavy industrial areas of hydroelectric power, pulp and paper machinery, nuclear energy plant equipment and railway rolling stock. In some instances, heavy industrial work has surpassed activity in the shipbuilding and ship repairing sectors especially during periods of slow shipbuilding demand, as has occurred in recent years. The flexibility of Canadian shipyards to take on major industrial work has enabled a number of companies to keep their trained workforce in place during dips in demand which at the same time has enabled them to expand into new markets.

Vessel under construction

CHAPTER 2

VESSELS AND FLOATING EQUIPMENTS

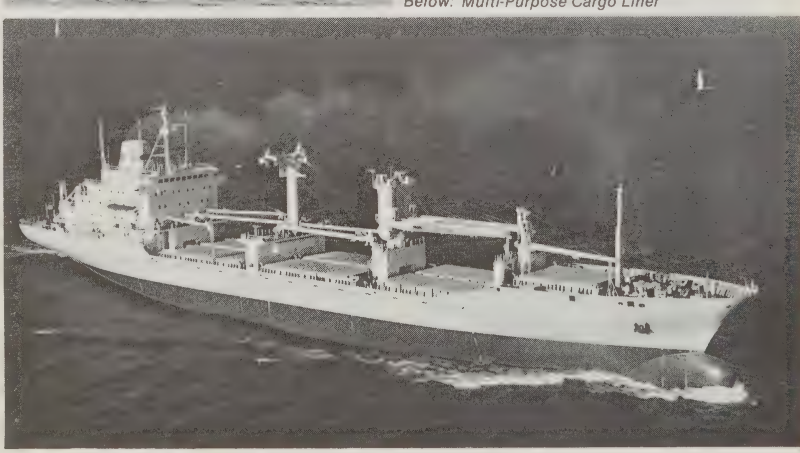


Introduction

For centuries, the primary function of merchant vessels has been to move goods or passengers or a combination of both from one location to another. To exploit the renewable resources of the oceans, fishing vessels have been used from the earliest times. Over the last two to three decades, other types of vessels and floating equipment have emerged, the majority for the exploitation of non-renewable resources.

Tuna Vessel under construction

Top: Self-Unloading Bulk Carrier
Left: Unique catamaran-hulled Commuter Ferry
Below: Multi-Purpose Cargo Liner



Types of Vessels and Floating Equipments

A great variety of types of vessels and waterborne equipments exist today — and new types are being developed at an unprecedented rate. To aid in understanding the different types and their variety and complexity, the following breakdown should help:

Merchant Shipping

The main types of merchant ships in international trade and the cargo carried are:

1) **Bulkers**
grain, iron ore, bauxite, sulphur, potash, salt and sand.

2) **Container Ships**
containers carrying mainly manufactured products.

3) **General Cargo Carriers**
heavy machinery, steel, aluminum, and general merchandise.

4) **Tankers**
crude oil and refined products.

5) **Specialized Ships**
liquefied natural gas (LNG), liquefied petroleum gas (LPG), forest products, chemicals, perishable foodstuffs and fruit, roll-on roll-off (RO-RO).

For the Canadian and North American trade, the chief types of merchant vessels and cargos are:

6) **Lakers**
bulkers used in the Seaway system carrying grain, iron ore and pellets.

7) **Self-Unloading Lakers**
bulkers (as described above) except that these vessels have integrated advanced loading and unloading gear.

8) **Product Tankers**
refined products for markets on both coasts of Canada and in the Seaway system.

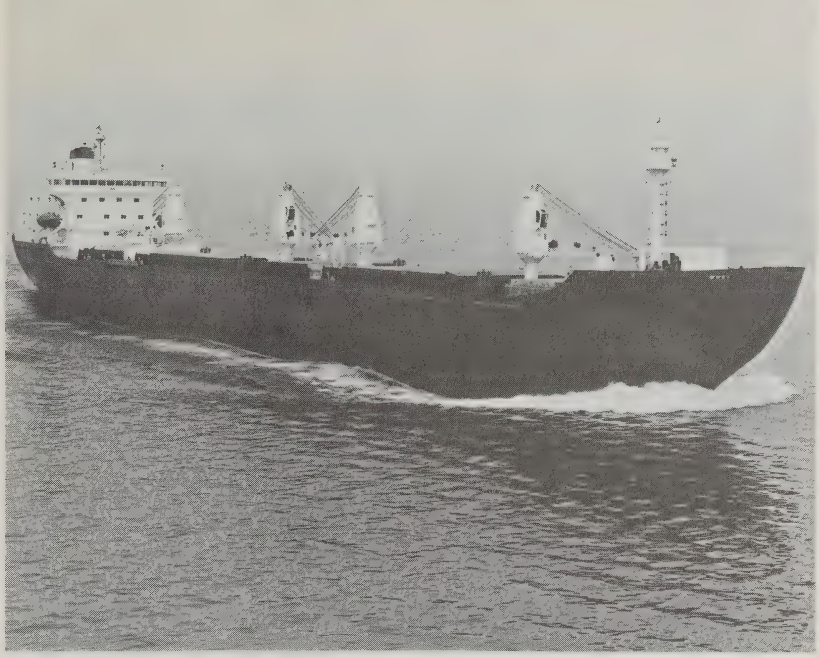
9) **Ferries**
passengers, truck road transports loaded with goods and to a lesser extent other cargo; on both coasts, in the Seaway system and on lakes and inland waterways.

10) **Self-Dumping Log Barges**
logs for markets on the West Coast of Canada

A 460 foot double ended Passenger-Car Ferry

Ice strengthened Passenger-Car Ferry

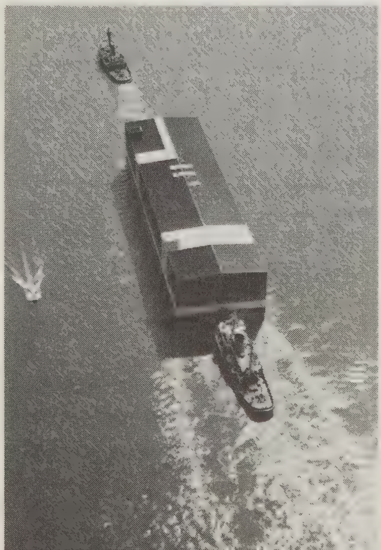
A 200 foot double-ended Passenger-Car Ferry



Heavily ice strengthened Bulk Carrier

Other Vessels

Other types of vessels used for transporting people and goods include: hydrofoils, hovercraft and cargo liners on scheduled services; small container ships used for feeder services; many types of barges and carriers; colliers and general cargo "tramp" ships.



Huge Barge mounted Ore Processing Plant in tow to the Arctic
Courtesy Cominco Ltd., Vancouver

Fishing Vessels

One of the largest groups of small vessels in Canada is comprised of trawlers and fishing vessels of all types and sizes. These range from small inshore fishing vessels of less than 50 feet in length to large offshore trawlers more than 200 feet long. The demand resulting from the need for modernization through replacement has been conservatively estimated to be worth more than $350 million per year. Included are large freezer trawlers to permit processing at sea.

Vessels and Floating Equipments Required for the Exploration and Exploitation of Non-Renewable Natural Resources in Waters, Some Ice-covered.

To explore and exploit ocean resources, various vessels and floating equipments are needed. In the urgent search for minerals and for oil and gas it is one thing to explore and exploit in cold but open waters and quite another to explore and exploit in the Artic and in the ice and iceberg infested offshore waters. Conditions are different and the equipments needed are different.

The types of vessels and marine structures specially designed for their roles in the Arctic and in the northern offshore waters include:

Jack-up Drill Rig

Self-Propelled Vessel Types

Arctic

Drill Vessels

LNG Arctic carriers

Icebreaking tankers

Icebreakers

Super dredges

Other ice strengthened vessels (supply, survey, crane, tugs, pipelayer)

Non-Propelled Vessel Types

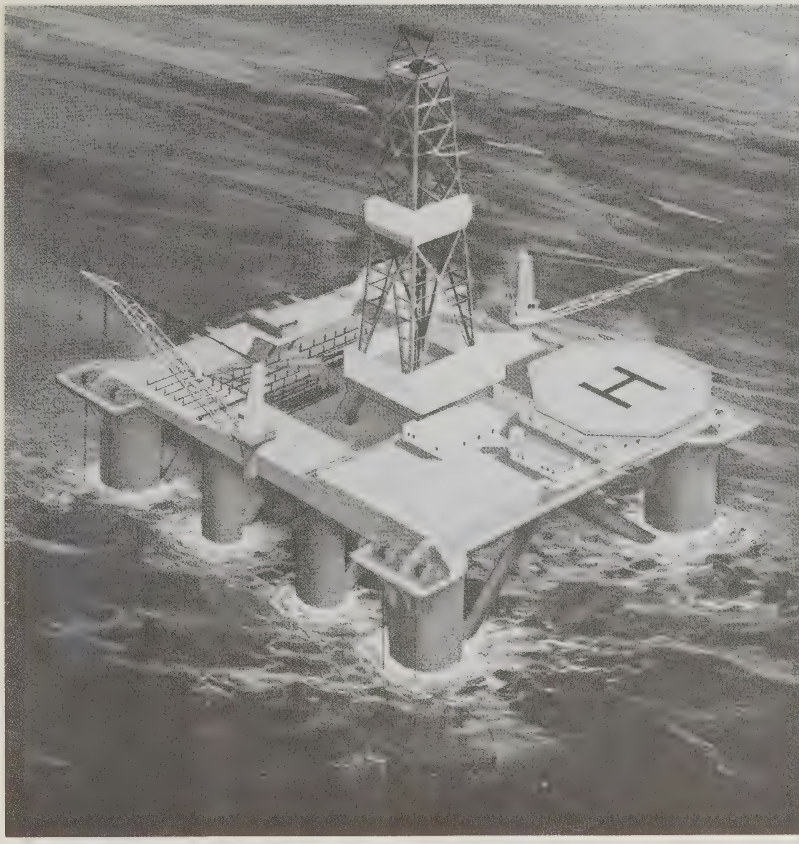
Arctic

Drill Barges

Semi-submersible platforms

Process & Storage barges

Accomodation barges and other barges



Semi-submersible Oil Rig

Self-propelled Vessel Types

Offshore

Drill vessels

Dynamically positioned semi-submersible platforms

Ice strengthened shuttle tankers

Other ice strengthened vessels (supply, service, tugs)

Non-Propelled Vessel Types

Offshore

Drill rigs

Semi-submersible platforms

Storage vessels

The common special requirement of these vessels and waterborne structures is that they be designed and constructed to withstand the very hostile environment and be able to be effectively worked year round. Hence, they are ice strengthened and are much larger, much stronger and much more powerful than standard ocean going marine craft.

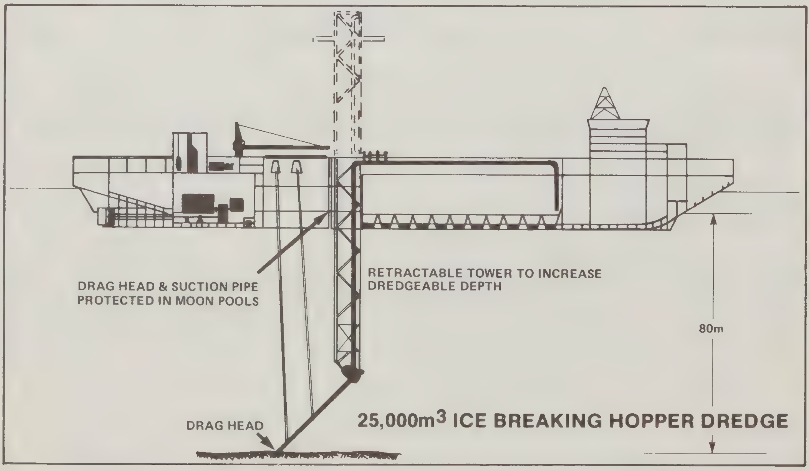
In addition to the drill vessels which are complex and fitted with advanced positional control equipment and a high drilling tower, there are two major types of conventional drilling rigs in operation. For deep water, dynamically positioned floating semi-submersibles are used: for shallow water, the jack-up type rigs with legs resting on the sea bottom are employed.

In the Arctic however, with the presence of ice, normal use of conventional steel platforms is not acceptable as they are incapable of withstanding the great forces created by moving ice. Large artificial islands designed and developed to resist the ice forces have been chosen as one of the means to provide protection to the exploration/exploitation equipments.

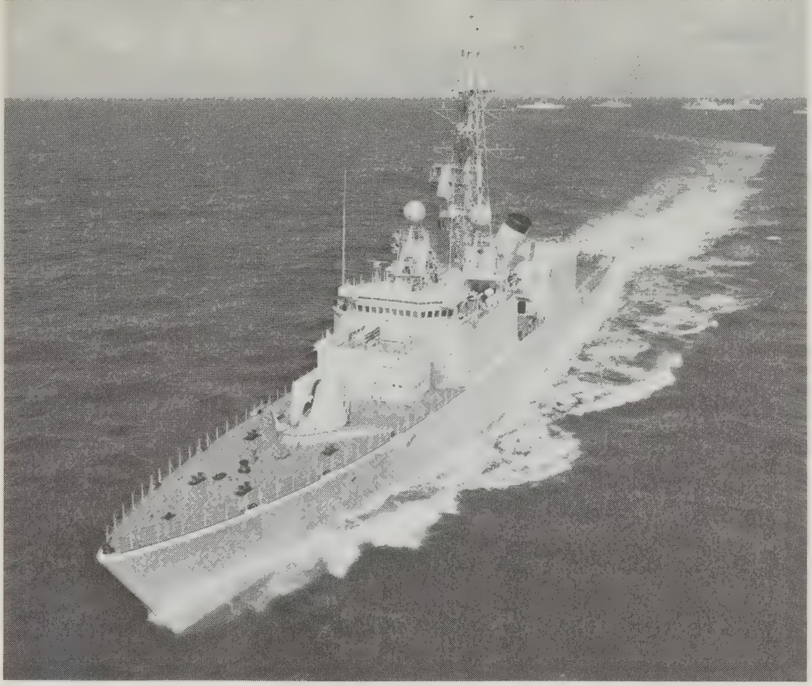
To make these islands, large super dredges lift material from the sea-bottom and transport it to the island sites. Drilling equipment and processing facilities are barge mounted and placed inside the islands to afford them ice protection. Very large icebreaking tankers will be relied upon to transport oil to southern refineries while icebreaking LNG carriers will move liquefied natural gas south.

As well, small submersibles (semi-submarines) especially designed for work on the seabed have appeared on the work scene in recent times.

The design and construction of the new unique vessels for use in the Arctic are at the forefront of technology and offer a great challenge to ship designers and shipbuilders.



25,000m³ ICE BREAKING HOPPER DREDGE



Guided Weapon Gas Turbine Destroyer
Courtesy of Canadian Armed Forces

Vessels for Special Duties

Vessels for defence, regulatory and safety-at-sea duties, research and fishery protection are all government owned and operated. They range from the most complex and sophisticated to relatively simple types. All are built in Canadian shipyards.

The Canadian Armed Forces have guided missile gas turbine powered destroyers, steam powered anti-submarine destroyers, submarines and fleet replenishment ships, the majority of which carry anti-submarine helicopters. The types of vessels in the Canadian Coast Guard include icebreakers, tenders for navigational aids and search and rescue vessels. Helicopters are often carried. The types of vessels in the Department of Fisheries and Oceans include oceanographic research vessels, fishery patrol vessels and small craft, some of which also carry helicopters.

The sophistication of the naval ships and the complexity of the larger icebreakers of the Coast Guard provide a great challenge to the Canadian shipbuilding industry. The building of these ships is one of considerable significance in its effects on Canada's future technological and industrial capabilities.

Other important types of special duty vessels are the coast-


Stern Trawler under construction


Canadian Coast Guard Rescue Boat

al, inland waterway and harbour tugs, and salvage tugs (tugs for use in the Arctic have been included in that section above.) In general, the coastal, inland waterway and harbour tugs are small but high-powered vessels. Harbour tugs assist larger ships when manoeuvering in restricted waters and in docking and undocking, while coastal and inland waterway tugs are used to tow or push log booms and barges loaded with forest and other products. Salvage and ocean-going tugs on the other hand are much larger and more powerful and are used to tow ships of any size in distress to a safe haven. As well, they tow oil rigs, large floating dry docks and other large structures such as the enormous barge mounted ore processing plant which was towed from Trois-Rivières, Quebec to Little Cornwallis Island in the Arctic in July/August of 1981.

Other vessels in this category include cable-laying vessels, tuna boats, dredgers, floating cranes, lifeboats, fireboats and pilot boats.

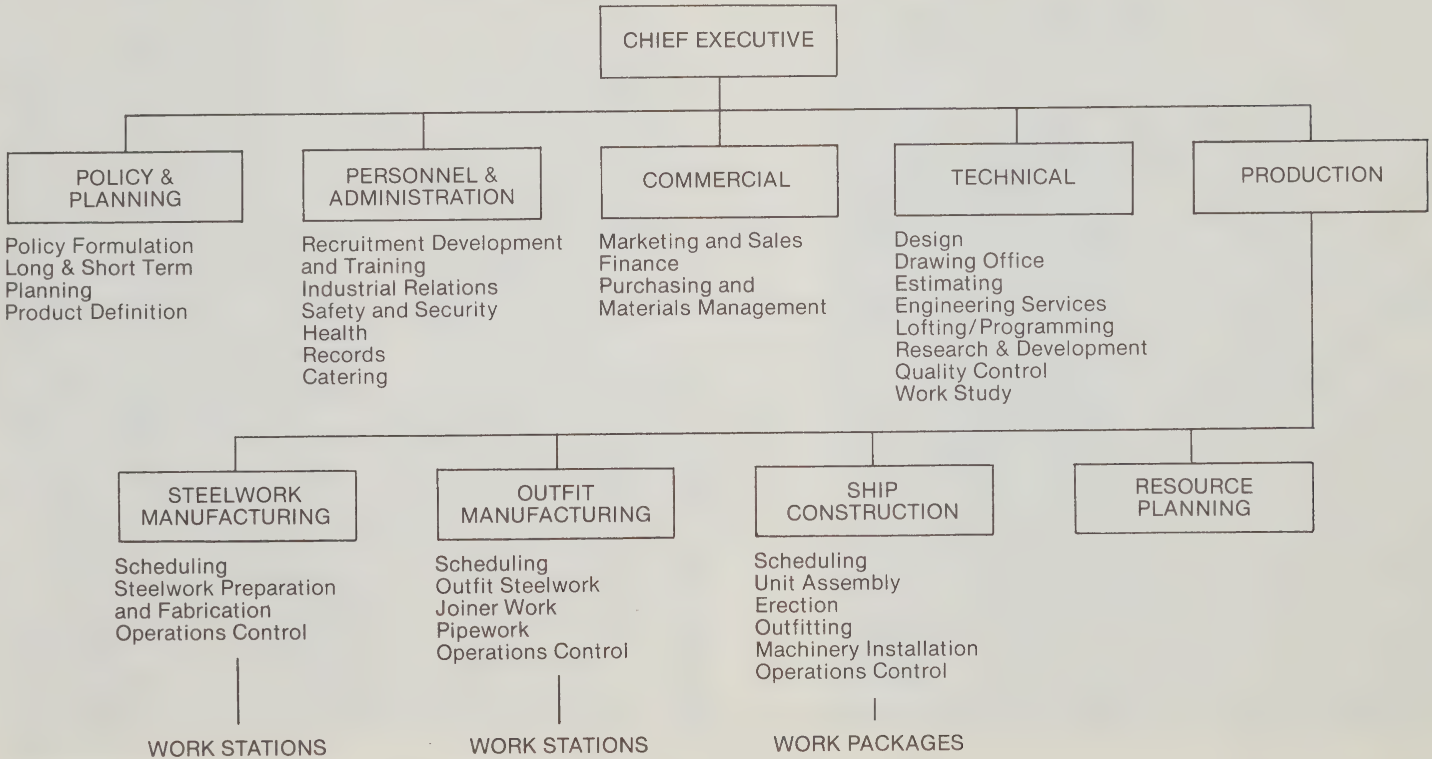
Recreational Craft

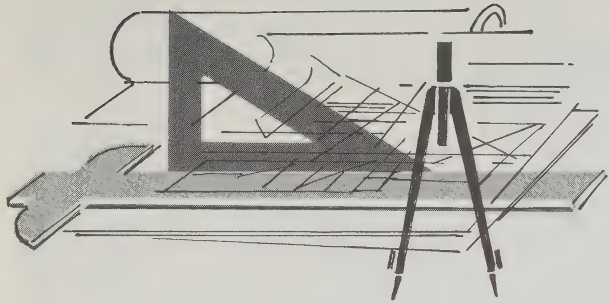
Greater affluence and more leisure time have led to an increase in the number and variety of recreational craft on the market over recent years. Among those available are sailing boats, cabin cruisers, motor-sail craft, catamarans and many other craft of all types and sizes. These craft are usually built in highly specialized small yards and shops and provide interesting and often painstaking work — and frequently offer the enthusiast a labour of love.

Pleasure Craft

FIG. 2

A TYPICAL SHIPYARD ORGANIZATION CHART





CHAPTER 3

TO BUILD A SHIP

Winning a Contract

The winning of an order for a new ship involves a search of the market, the identification of potential buyers, the preparation of a preliminary vessel design, an estimation of cost and the submission of a bid. Further negotiation normally follows before a contract is signed. Shipyard staff involved in the winning of a contract are highly qualified and invariably include senior management, marketing personnel, naval architects, marine engineers, lawyers and accountants.

Once a contract is signed the detailed design and production of working drawings are put in hand; steel, equipments and materials are ordered and production scheduling planned. Building then commences but before the vessel is delivered the vessel and all its machinery and equipment must be tested and operated in harbour and at sea to ensure performance and seaworthiness in accordance with the specifications laid down in the contract.

In the pages which follow more detail is given on how a shipyard is organized and operated, and a closer look is taken at the procedures involved to create a complex vessel from the words written in the contract.

Shipyard Organization

Although the organization of shipyards varies from one to another particularly between larger and smaller yards, the functions to be performed are basically similar. The purpose of organization is to delineate the duties and responsibilities of groups within a yard and the people within them to effect the coordination of all.

With an organizational structure in place, efficient and harmonious operations should ensue to ensure that ships of quality are built on time, at the right price and at a profit. A typical organization for a large shipyard is outlined in Figure 2.

Policy and Planning Group

To be successful, policy guidelines must be defined for senior and middle management and all others of the shipyard to follow. Long and short term planning is then carried out within these guidelines so that shipyard development proceeds in a timely and rational fashion. In addition, overall planning must be coordinated to ensure that the necessary funding, material, personnel and facilities needed to build a ship by a certain date and at an agreed price are available before a contract is signed.

Shipyard Marine Railways and Transfer Ways

Marketing

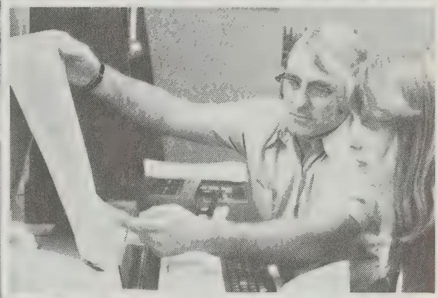
Marketing may take a number of forms but in essence it involves the continuing search of the likely demand from shipowners for vessels and waterborne craft. From the information gleaned, and subject to shipyard capacity available, shipbuilders may seek one or more contracts. On the other hand, shipbuilders may ignore much of the marketing information received in favour of particular types of ships in which they are interested. In such a situation they might seek other buyers hoping to receive multiple orders to allow series production and hence a lower selling price.

Finance

The "keeper of the purse" is responsible for keeping track of the flow of money and for ensuring that the company remains solvent. This involves the use of capital resources to the best advantage of the firm, to balance expenditure for material, equipment and labour with construction progress payments, to prepare financial statements, to analyse the efficiency of individual departmental operations as well as the company as a whole, and to provide financial advice to management.

Selection of fabrics for outfitting ship

Regular production planning meeting



Reviewing production data

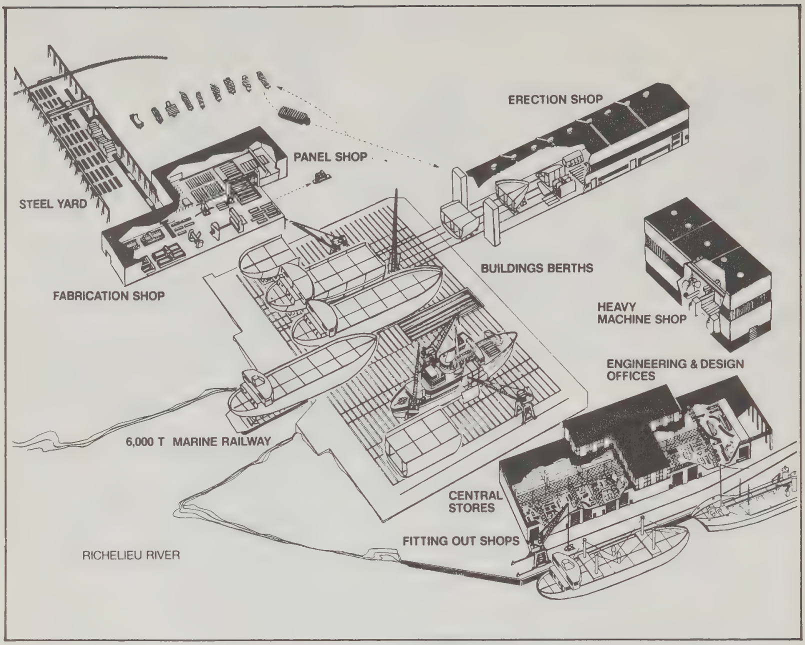
Computer-aided drafting

Purchasing and Material Management

As the name implies, this department carries out the timely purchase of all materials and equipments to meet the needs of the firm with particular emphasis on those of the production division. The purchasing function involves the request for and acceptance of quotations, the placing of orders and not least of all the disposal of scrap.

Personnel and Administration Group

The main functions of this division cover organization; workforce planning, recruitment, development and training; industrial relations; safety and health. As well, this group negotiates and administers wages and conditions of employment. These functions are very important as the firm's human resources represent the most valuable assets of the firm. Without harmonious working relationships and good working conditions it is difficult to attain and sustain a high standard of efficiency.



Graphic layout of a shipyard

Technical Group

When shipowners perceive the need for a new vessel, they determine the operational and technical requirements of the vessel. Normally included in the owners' statement of requirements is the type of vessel and propulsion plant, the desired economical speed, the endurance, the frequency of service, the type and quantity of cargo to be carried, the type of cargo-handling equipment desired, the number of the crew, the navigation, radar and communication equipments needed and so on. Often a number of yards are asked to respond.

On receipt of the owner's statement of requirements, the technical staff of a shipyard (naval architects, marine engineers, draftpersons, estimators and planners), translate the requirements into linear dimensions and the required form. The naval architect(s) ensures that the vessel's hull is streamlined for maximum fuel efficiency and that it is stable and strong enough to withstand not only the static loads due to cargo but also the forces likely to be encountered in the various sea states. The engineers ensure the selection and efficient layout of the most economical propulsion and electrical power system, cargo handling arrangements and other systems and equipments in the ship. Economy in building is constantly in mind during this estimating and planning stage.

Three principal drawings are then prepared to define the final design of the vessel. These

Preparation of production drawings

drawings are called the General Arrangement, the Lines Plan and Midship Section.

The Lines Plan is important as it forms the basis of the other plans and shows the complete form of the ship in three mutually perpendicular planes. The General Arrangement Plan which comprises the elevation and plan views of each deck shows the internal layout of the various compartments, spaces and tanks (accomodation, navigation, main machinery and cargo spaces; fresh water, oil fuel and ballast tanks). The Midship Section Plan which is normally a transverse section of the hull at about midships, shows the sizes and shapes of the main structure.

On completion of these plans an estimate is made of the building costs. Overhead is added as is an allowance for profit. The tender normally comprising the principal drawings described above, the dimensions, capacities, technical specifications, price, delivery date and method of payment, would then be submitted to the owner. Should the shipowner accept the tender, a contract would be signed.

Detailed production drawings of all the various parts of the ship would then be prepared. The purchasing department would place orders for steel, other material and equipments and production scheduling would be commenced in preparation for building.

Plate emerging from paint priming ready for fabrication

Facilities Needed

General

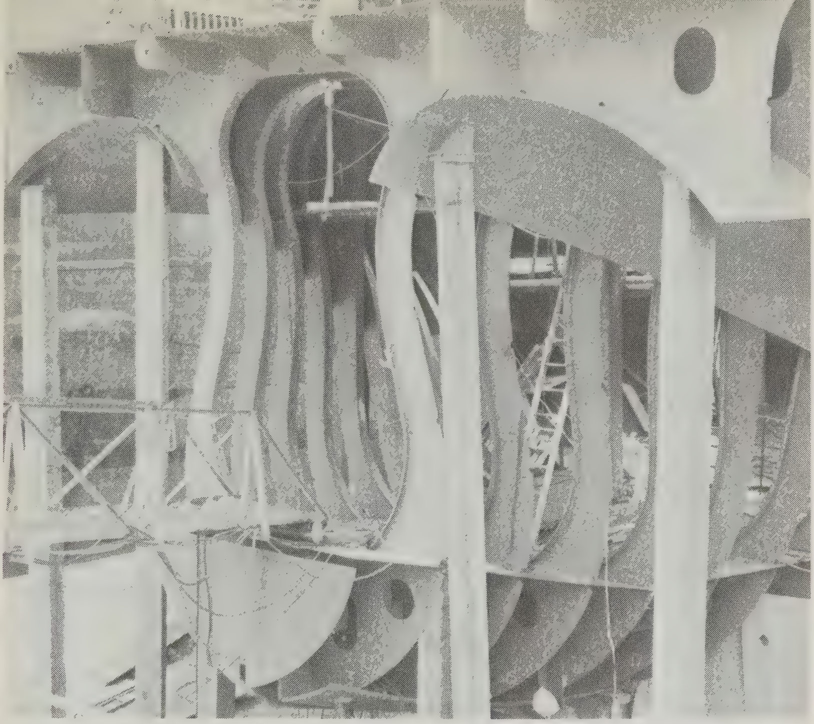
A ship is built in a shipyard which in essence is a factory with direct access to water of reasonable depth. The yard consists of buildings for the manufacture of components, and berths, slipways or building docks where final assembly of the hull takes place and from where the vessel is launched into the water.

The design and layout of a shipyard is important if efficient and orderly flow of material is to take place from the point of receipt, through preparation, machining, sub-assembly, fabrication and final assembly on the building berth.

In the pages which follow a brief description is given of the major work stations and the main machinery needed in each.

Steel Stockyard

Steel is the basic material used in the majority of ship constuction and as the quantity used is considerable, a large area must be set aside in the shipyard for the sorting of the steel as it arrives from the steel mills and for its subsequent control. Special material handling equipment such as magnetic cranes and conveyors are needed for handling the steel shapes and plates within the steel stockyard and to move the steel on its way to the various preparation shops.



Strengthening of stern of vessel

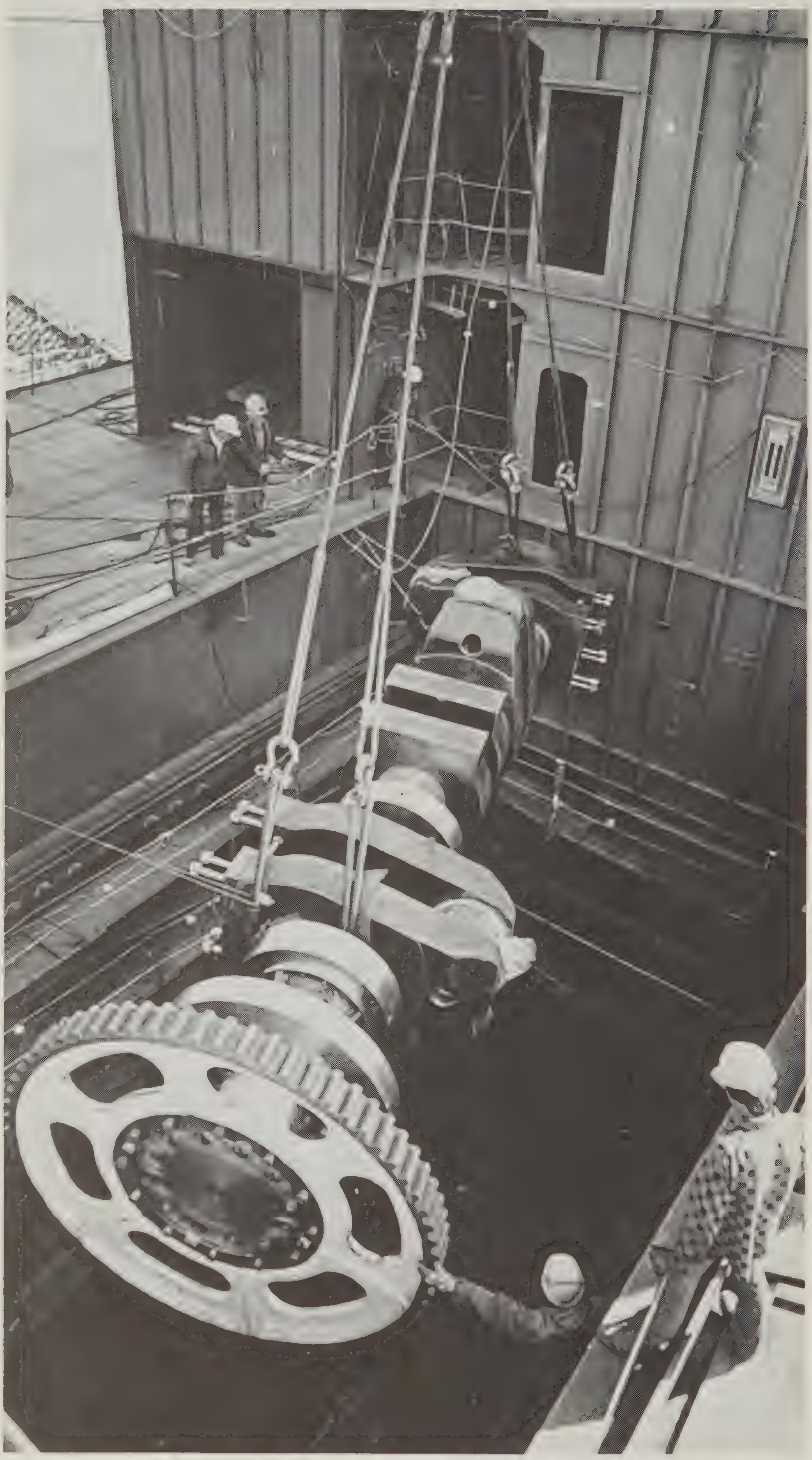
Steel Preparation Shops

The steel on receipt from the steel mills is usually covered in mill scale and rust and often is slightly distorted. Consequently, the plates have to be straighten and must be stress free to permit their welding. The machinery used is a set of heavy plate straightening rolls which relieves the residual stresses by stretching the plate beyond its elastic limit as it is rolled.

The mill scale and rust are then removed by shot blasting to provide a clean, rust-free surface which is immediately coated with a quick drying primer.

Having cleaned and primed the steel plate (which in some yards is part of the steel stockyard operation) the steel preparation shops then convert the plates and stiffeners into the shapes and sizes desired for assembly. Plates of straight edges or rectangular shape are cut by flame planers which cut two or three sides at once using oxyactylene or oxypropane torches. Other plates are cut by hand or by machines controlled by electronic means from accurate scaled drawings of the part or from computer prepared paper tapes. Lighter plates can be cut mechanically.

For the bending or curving of plates, roll bending machines are used. Light stiffeners are usually bent by rolls while larger sections used for hull stiffening are formed by special frame benders.



Lowering of main engine crankshaft into vessel

Fabricating sub-assemblies

Fabrication Shops

The plates and stiffeners which have been cleaned, primed, cut and formed as briefly described above are joined together by welding in the fabrication shops. Usually, a separate shop or one part of the main shop is dedicated to the joining together or fabrication of relatively small parts into components called sub-assemblies while the larger part of the main shop is used to fabricate large sections called "blocks" or "modules".

The shop(s) have special handling equipment for positioning of the pieces to be welded and for the subsequent movement of the fabricated parts to the next work station. Compressed air, electricity and gases together with welding equipment are part of the outfit of the fabrication shop.

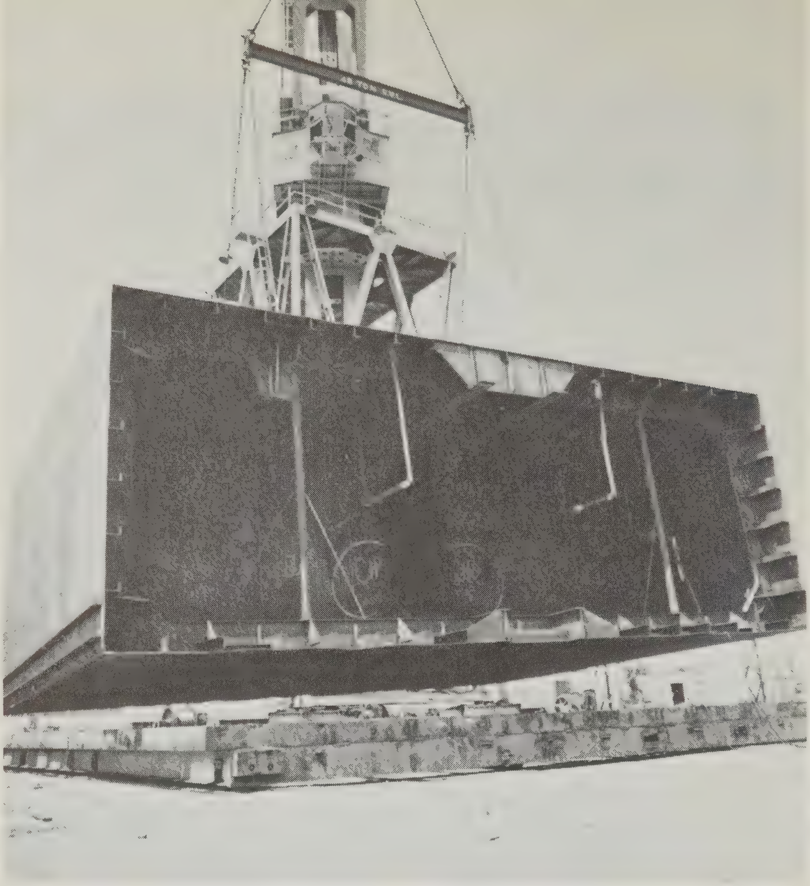
The next work station for the fabricated parts is usually the building berth or the building dock where the various sections are welded together to form a complete hull.

Building Slips or Berths

A building slip is a level or an inclined launching berth on which the ship is built. These are usually at an angle to the water or alongside it. The slipway at an angle to the water permits launching by the stern whereas the slipway alongside the water, facilitates a broadside launch.

The layout of building berths, of which normally there are a number in a yard, requires careful planning to ensure that the alignment of the slipway relative to the water permits the best use to be made of the available depth and breadth of water. Reinforced concrete is usually used for construction of a slipway, which must be of sufficient strength to take not only the weight of the vessel during construction, but also any additional stresses induced during launching. Travelling cranes of high lifting capacity and of sufficient reach to provide coverage of the berth and the surrounding areas used for temporary storage of fabricated sections and equipments, are installed over or adjacent to a berth.

In recent years, many new and existing building berths and docks have been enclosed, thus permitting more efficient assembly unaffected by seasonal conditions and inclement weather. Perhaps more importantly, an enclosed plant considerably reduces the risk of not meeting the delivery date of the vessel due to factors beyond the control of the shipbuilder.



Fabricated block ready for installation

Building Docks

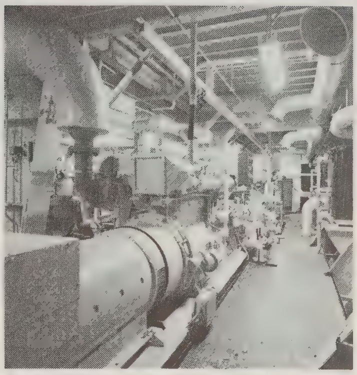
The building of a vessel in a dry dock has been practised for many years. Although the capital cost of constructing a dock is very considerable these days, many shipyards throughout the world installed building docks for the construction of very large bulkers and tankers during the 1960's. Other yards have used their repair docks for building larger ships. The advantages include better access by cranes alongside the dock, a level construction platform and elimination of the risks involved when launching a large ship.

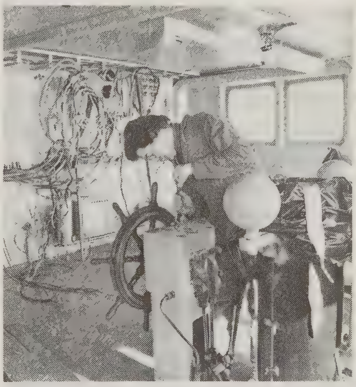
Marine Elevators and Transfer Facilities

Increasingly in recent years marine elevators and associated transfer facilities have been installed in shipyards for the building and repair of vessels. These shiplift systems come in a variety of sizes up to 650 feet long and 100 feet wide with a lifting capacity of up to 48,000 deadweight tons. A number of shipyards/dockyards on the east and west coasts have added these facilities which provide greater flexibility and higher productivity in the building and servicing of vessels.

Cafeteria
Ferry lounge

Part of an engine room
Outfitting on the bridge

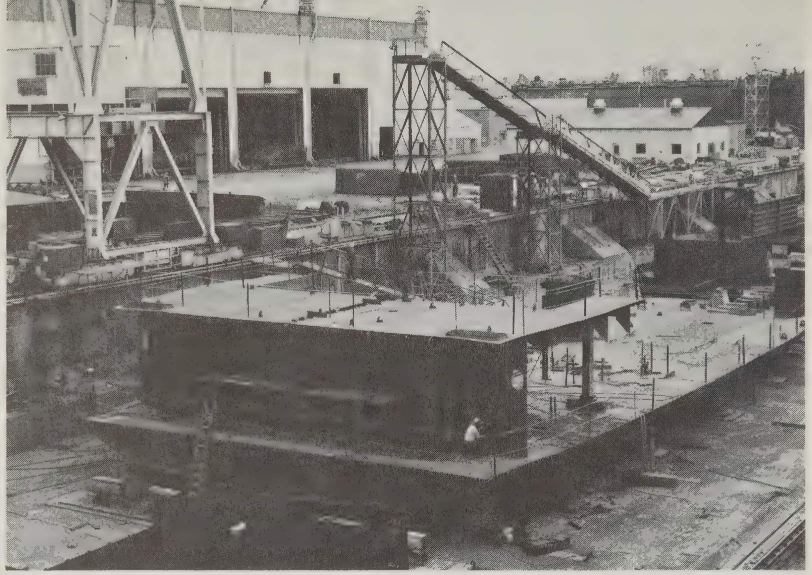




Outfitting

Although the current trend is to outfit the steel fabricated sections as much as possible before and during erection on the berth or in the building dock, some of this work is carried out after the ship has been launched and moved to the outfitting quay. In general, the main fitting-out shops involved are: pipe shop, joiners' shop, electrical/electronics workshop, sheet metal shop, fitting shop, paint shop and rigging shop.

The extent of the outfitting load within a shipyard depends on the types of vessels being built and to the degree to which the work is sub-contracted. In a shipyard where warships and passenger vessels are built, extensive facilities are needed, whereas the outfitting required in a cargo vessel or tanker is much less.



Fabrication of a vessel

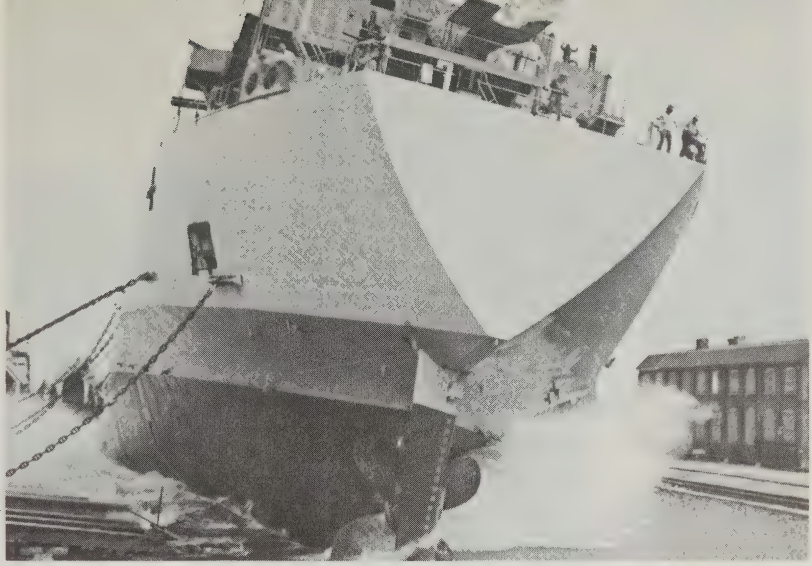
Vessel Assembly and Installation of Equipment

The laying of the keel used to be one of the first steps if not the first, in the building of a vessel. Today, this is usually preceeded by the fabrication of modules or "blocks" of various sections of the ship to minimize the time a berth is in use for the building of an individual vessel. When the assembly of individual modules is well advanced, steel erection on the berth is started. As steel erection is progressed, machinery including the main engines, gear boxes, shafting and other equipments and components are put in place. The modules previously assembled are then transferred by cranes for installation in the vessel on the building berth and other outfitting such as piping and electrical work is progressed as fabrication proceeds.

The electricians install all cabling and wiring throughout the ship for lighting, heating, ventilation, refrigeration, machinery; for navigational aids such as gyro-compasses, radar, radio and echo sounders; for cargo-handling equipment such as winches and cranes; for deck services such as windlasses and capstans, and so on. The fitting and plumbing departments install all pipework in the ship, including domestic services, ballast, fuel oil, lubricating oil and liquid-cargo handling systems.

At this time, any sub-contractors installing equipments and items such as ventilation, refrigeration, insulation, navigational aids and special machinery would have tradespeople on board carrying out this work.

Inspection and testing of the steel structure is carried out with all important welded seams subjected to radiography.



A broadside launch

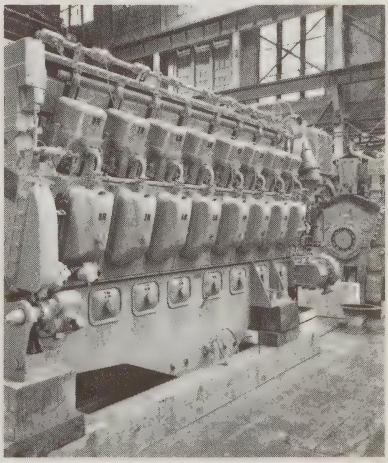
Launching the Vessel

Vessels are usually built on inclined building berths from which they are slid into the water when the hull and some of the outfitting has been completed. The operation of placing the vessel's hull in the water is called a "launching" which consists of transferring the weight of the hull from the keel blocks on which the vessel was built, to the greased inclined lauchways allowing the vessel to slide by its own weight into the water. The launching of a vessel is usually the occasion of a special ceremony in which a "sponsor" invariably a woman, named by the ship's owner, breaks a bottle of champagne on the bow at which time the shipyard staff trigger the release mechanism.

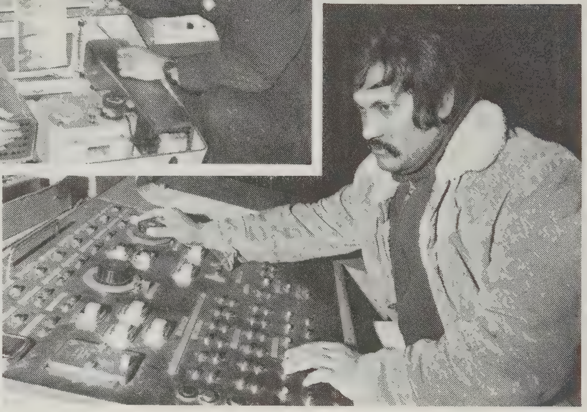
When a building dock is used for the construction of a very large ship and the hull is complete, the dry dock is flooded and the dock gate opened and the ship towed out.

One method used to overcome the problem associated with launching large ships from an inclined slipway has been to build the ship in two parts, with each part launched separately and then joined together when afloat.

Main engines being fitted



Installing sonar display unit in wheelhouse



Checking out systems

Completion of Outfitting, Testing and Final Trials

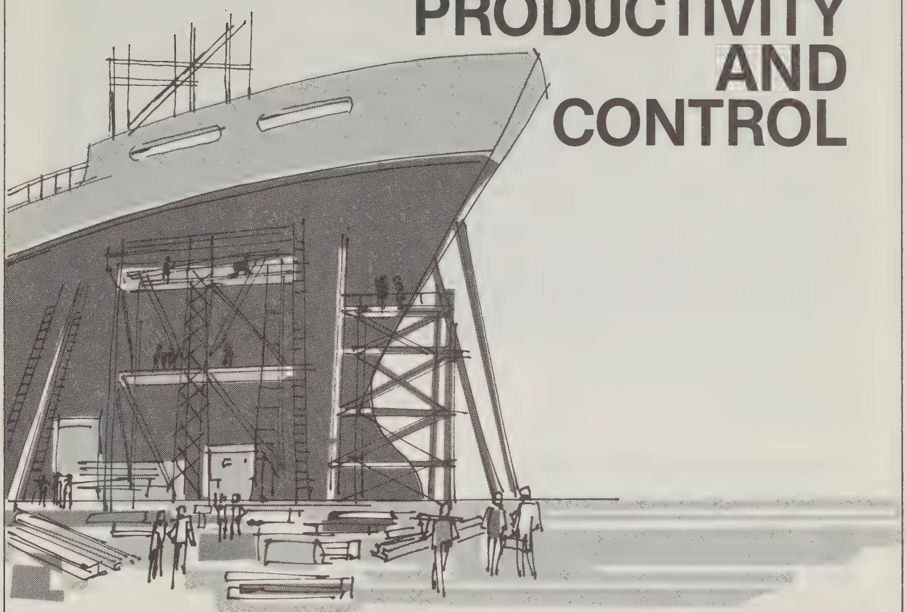
When the hull is in the water, it is towed to an outfitting wharf where vessel construction, outfitting and testing of equipments and systems, the fitment of furnishings and not least of all painting is completed.

Compartments such as liquid cargo tanks, fuel oil tanks and ballast tanks which are subjected to liquid pressure are tested to prescribed pressures by heads of water or compressed air. The main engines and associated gear boxes, shafting and auxiliary machinery are also tested, as are all cargo-handling equipments to a specified overload. All electrical circuits and electrically driven machinery are similarly checked out. All piping systems such as the firemain, fuel oil, ballast, lubricating oil and fresh water are pressure tested when installation is complete. In fact, every item of working equipment and every system must be proved to the satisfaction of the owner's representatives and to the government ship inspectors or the surveyors of the classification society, as applicable.

Finally, sea trials are conducted to demonstrate to the shipowner that the vessel is seaworthy in all respects and that all the conditions of the contract and specification have been met. These trials at sea include anchor and steering trials, as well as the establishment of the correct relationship of speed, power, engine revolutions and fuel consumption. On the successful completion of all trials a Classification Certificate is issued, signifying that the vessel has been "well and truly built." This is one of the essential documents required when the shipbuilder hands over the vessel to the owner.

CHAPTER 4

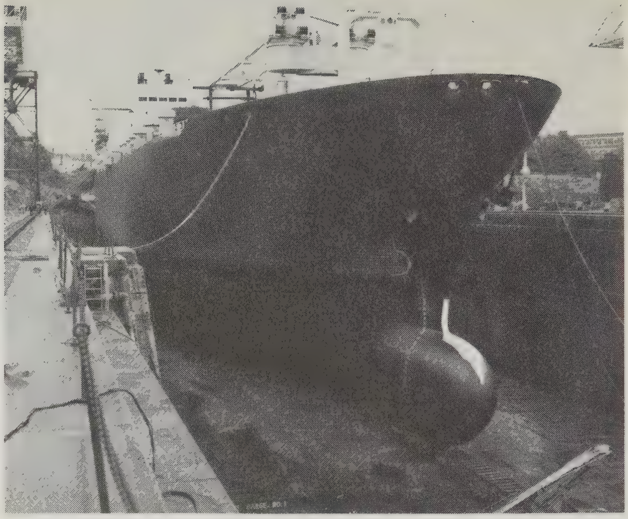
PRODUCTIVITY AND CONTROL



Ship Production Technology

With the advance of technology and the increasing demand for larger, more powerful and more complex vessels from an industry which is fiercely competitive, individual shipyards have been under pressure to improve productivity to reduce costs. Consequently, over the last two or three decades, fundamental changes in ship production technology have evolved. An example has been pre-erection outfitting. A reduction in work content has also been achieved by good production engineering where for example weld length may be reduced through use of larger and wider plates and stiffeners. As well, many yards have made enormous improvements in material handling, assembly line technology and cutting and welding processes.

The full potential of these developments, however, cannot be achieved unless the material, up-to-date information and resources are brought together at the right place and at the right time and that the resources are kept loaded continuously at the desired level of performance. This can be achieved by the scheduling of the work and the application of good management practice at all levels in the shipbuilding production process.



Vessel in Graving Dock

Coordination and Control

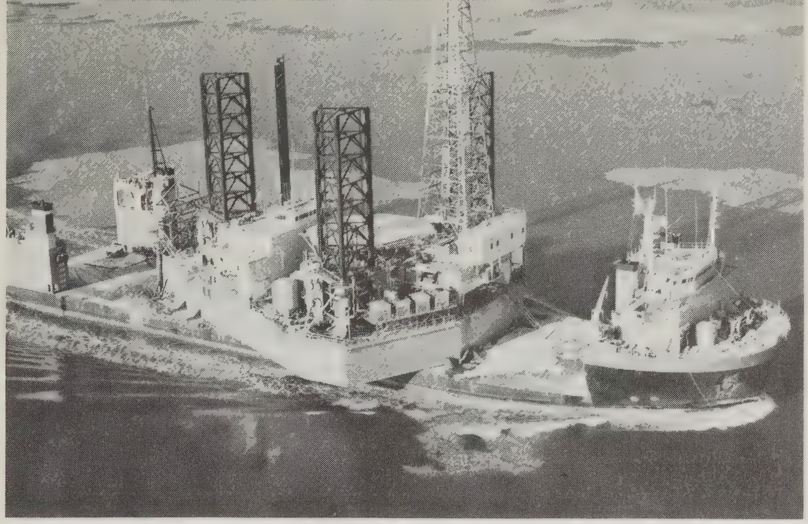
To improve the quality of the information flow a much greater alignment between production management and the production planning staff of many yards has taken place. Joint discussions at each level normally occur between production control staff and management to set control targets and to take regulatory decisions. At the work station level, the operations control team assist foremen/forewomen to manage their workload and to coordinate the flow of work through the production process.

Looking at production control in terms of the total information flow the case for or against the use of computers can be determined by the amount of information to be processed. In small shipyards, manual procedures are often quite adequate.

In larger yards, particularly where the variety of vessels being built is high, computer processing is probably necessary. However, in the final analysis, the quality of the information derived and the time taken to provide the information will dictate the effectiveness of control.

The assembly flow process of shipbuilding can be modelled in the design of an information system, with each module or part of the system using techniques and procedures suitable to a particular production area. This supports management decision taking by supplying the right information at the right place at the right time.

The concept of the work station is important. As the smallest plausible production unit, it structures the requirement for technical information which is supplied by the technical department often in the form of work station drawings. In addition, the work station provides a physical location for material delivery, as well as a useful one for timekeeping and for meaningful performance measurement as a control mechanism.



Jack-up Drill Rig being delivered by barge to owner

The Ship Production Control System (SPCS) outlined below is an approach to production scheduling and control which is being used in shipyards in Canada and other countries. It is a methodology, with each of its eight modules being a relatively self-contained management system for shipyards and mixed new-building / repair yards.

Corporate Planning and Scheduling

The corporate planning module seeks to establish over the medium to longer term, the effect on the company of major changes in the order book, vessel type and price, material costs, productivity, wage rates, worker availability and redevelopment of the shipyard.

The output from the module provides information on personnel use, steel throughput, berth and quay occupancy and key dates for keel laying, launch and completion, costs and cash flow for each ship and for all ships being built.

The approach to resource planning and budgeting makes use of the technique of manipulating cumulative curves of workforce and money expenditure linked to a simple production schedule. Thus, it is possible to aggregate the demands of the whole shipbuilding program, interspersed where relevant with ship repair work, and derive the resource requirements for the company over time.

Normally, a library of ship production models is maintained, with each ship model containing details of the production method and associated material and personnel requirements for each type of ship. Furthermore, representation of the workforce requirements by normalised S-curves for each of the major trade groupings, allows the effects of increased production efficiency and variations in production times to be investigated.

Main Contract Scheduling

This scheduling is a set of methods and procedures for determining the cardinal date program for each ship production contract. The heart of the contract planning module is the erection schedule. By incorporating this schedule within a bar chart or network of both pre-production activities with those of the production department, the overall budgets of time and resources for each vessel being built/repaired can be coordinated. The major output is a set of demand schedules on each shipyard department which forms the basis for more detailed scheduling in other modules.

As ship production times decrease in response to the demands from shipowners for shorter delivery times in a competitive industry, the pre-production functions must become more effective. Depending upon the complexity and size of the vessel, a set of established lead and lag times or a network capable of manual processing is used. Key dates for owners, classification societies and other regulating approvals are highlighted as are key dates for delivery of major items of equipment.

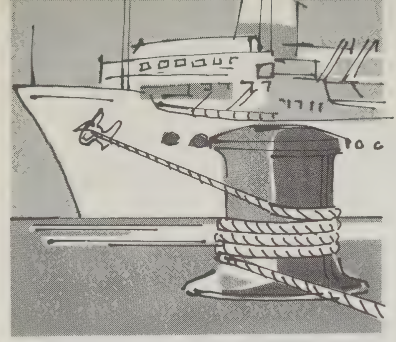
Steelwork Scheduling and Control

This module reflects the organization of work at the shop floor level, the definition of work stations and the extent of the production lines. It covers the creation of a steel plate, stiffener and parts database, the control of steel purchasing and delivery, and the scheduling and control of steelwork production.

The shipyard technical departments which have initial responsibility for the generation of parts data, identifies nested piece parts with plates and stiffeners, detailing thicknesses and scantlings to enable material to be ordered. A parts register which forms the central core of the database is created and individual plates and stiffeners are correlated with units and their respective demand dates. Units are analyzed and the work to be carried out at each work station is calculated. Similarly, the materials required for each production process and the parts or assemblies to be manufactured are defined.

Steel is purchased on information provided by the drawing office. Orders are checked on receipt of the steel and withdrawals are recorded thus permitting a balance to be calculated.

Regarding steelwork produc-



tion scheduling, there are many acceptable schedules available. In effect, the job lists for the different production routines are spread across the available work stations. Each job has an indicated operation time based on its work content and the facilities available. The efficient achievement of the production schedule depends upon the skill of the operations control function on the shop floor, a function largely performed by foremen / forewomen and operations control staff. Efficiency however, is largely dependent on the ability to readily gain information on the material status at each work station and the ability to quickly rationalize the implications of alternative courses of action.

Manual visual displays are often used to show the workload and the status of each work station but in advanced facilities, it is more efficient to access the database by means of an on-line computer via visual display units.

Management information is generated at this stage, thus permitting each foreman/forewoman to monitor his/her own performance while production management is able to isolate the cause of production deficiencies.

Block Assembly and Steelwork Erection Planning

As described earlier, the initial block erection schedule is prepared during the main contract scheduling and forms the basis for the preparation by the module of detailed schedules for block assembly by the ship construction work stations. This schedule will also make allowance for advanced outfitting as described later.

An operations control function responsible for monitoring production is included in this module. Manual visual displays or an on-line computer with visual display units are used to show the status of work.

Outfit Installation Scheduling and Control

This module produces the overall schedule for outfitting the vessel by using a bar chart or network to sequence and give the start dates for installation work packages. It also identifies the requirement dates for bought or yard manufactured material as well as the manpower requirement. The work station principle is applied to outfitting by dividing the vessel into a number of zones with the work to be carried out in each zone, considered as a set of work packages. By interfacing the networks for all of the zones, an overall network for ship installation is built up. Resource requirements are aggregated and smoothed to give a feasible outfitting schedule.

Fuel and stores replenishment-at-sea

Installation Parts Control, and Purchase and Stores Control

Installation Parts Control is a specification of all outfit items whether bought from suppliers or manufactured in the yard. Against each item pertinent information is added regarding (1) zone and work package; (2) supplier and order number; (3) delivery status and stores location; and, (4) whether it is to be included in an advanced outfit package.

The aim of these two modules is to ensure a timely and orderly flow of material through the yard so that it is available for installation at the right time and at the right place.

Outfit Shop Scheduling and Control

This module creates and maintains a technical database for all piece parts. The parts information is drawn from manufacturing drawings produced by the technical department and is used to produce detailed shop schedules to match the demand schedule for installation parts manufactured in the yard.

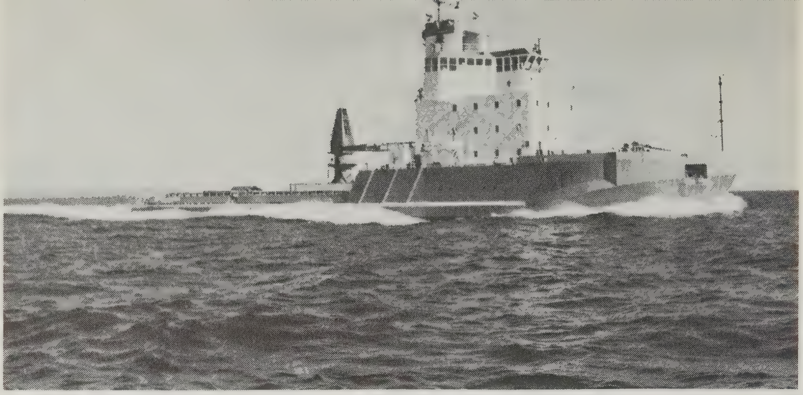
With good liaison between the Installation Parts Control, the Purchase and Stores Control and the Outfit Shop Scheduling and Control Modules a unified pattern of material control can be developed for all material on a specific ship contract.

CHAPTER 5

THE ALLIED INDUSTRIES

Introduction

When a shipyard wins an order to build a ship, the yard commits itself to building it to the operational and technical requirements of the owner. The requirements may vary considerably from ship to ship and from owner to owner, not only in type and size of vessel but also in the machinery and equipment to be installed. Shipyards cannot conceivably manufacture the great variety of components and material required and are thus in varying degrees dependent on "suppliers" and subcontractors.

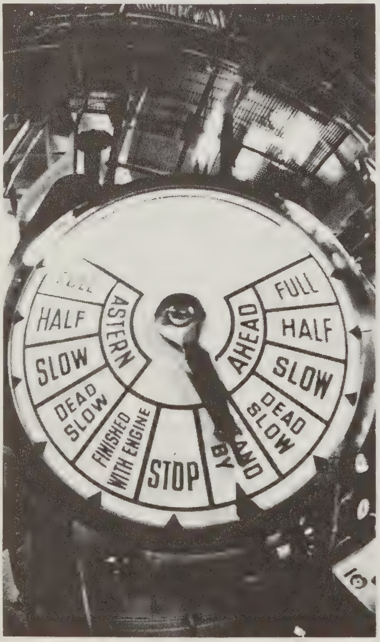


Icebreaking Anchor Handling Tug

Material, Machinery and Equipment Suppliers

With over fifty percent of the cost of a vessel attributable to the procurement of material, machinery and equipment, the industries supplying these products represent a very significant and essential part of the shipbuilding operation.

An indication of the products normally supplied by the allied industries are:



Bridge/Engine Room telegraph

Air Conditioning equipment
Anchors
Auto Pilot Systems
Boilers & associated equipments
Bollards
Bow thrusters
Bronze fittings
Cabin fittings
Capstans
Cargo handling equipment
Communications equipment
Compressors
Cranes
Deck coverings
Davits
Depth recorders
Desalination equipment
Dredging machinery
Echo sounders
Electrical components
Electronic components
Elevators
Engines — main
Fans
Fire protection systems
Fishing equipment
Galley equipment
Generators

Tug towing barges, equipment and stores to Arctic

Hatches & hatch covers

Heat exchangers

Heating & ventilating equipment

Hydraulic components & systems

Insulating material

Lifeboats

Metals — steel plate, special steel & non-ferrous alloys

Navigation aids

Oil purifiers

Paints

Piping and pipe fittings

Propellers, shafts and shaft brakes

Pumps

Radar & associated equipments

Refrigeration equipment

Rudders

Seals & Packings

Ship cargo loading and unloading equipment

Sonar systems & equipment

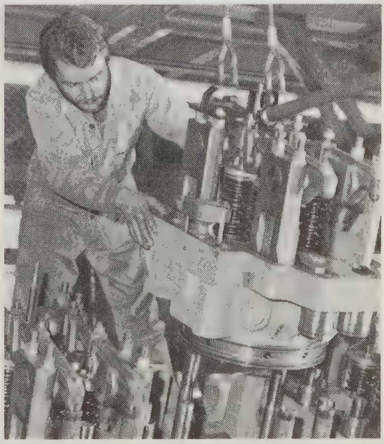
Stanchions & railings

Steering gear

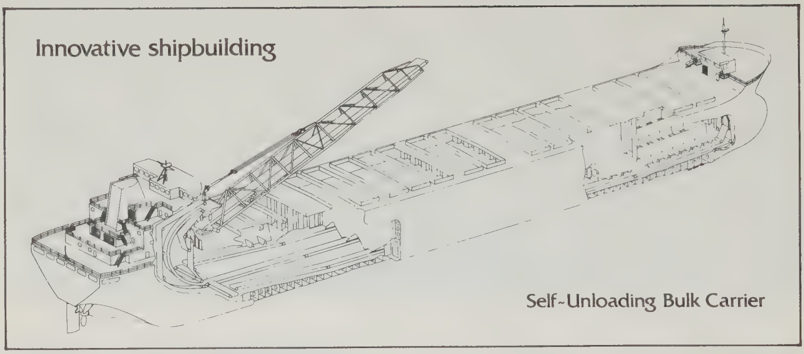
Water treatment equipment

Winches & windlasses

The personnel involved in the supporting allied industries must be well qualified. The skills required include design; marine, mechanical, electrical, electronic and oceanographic engineering; scientific research and development; metallurgy; human engineering; computer programming and operation; business administration; accountancy; drafting; quality assurance; welding; metal working; machining and engine fitting; electrics and electronics; communications; underwater acoustics; signal processing; carpentry; hydraulics; refrigeration; and many others as well as marketing and those of senior management.



Engine fitting



Consultants and Designers

With the advance of technology and the increasing demand for larger, more powerful and more complex vessels such as the Arctic LNG carriers, icebreaking tankers and other large structures at the leading edge of new technology, the trend has been for an increase in the number of specialist consulting and design firms. Increasingly, prospective owners hire such firms for advice and for the design of unique vessels. Similarly, shipbuilders may use the services of these specialists when the requirements for a unique vessel are beyond the scope of their in-house staff.

An indication of the specialties of some of the consulting and design firms in the marine field are:

Naval Architecture

Model Testing

Marine Engineering

Sea Transportation — Arctic & Otherwise

Ocean Engineering

Fisheries Technology

Helicopter Operations at Sea

Marine Maintenance Systems

Materials Handling Systems

Project Management

Set to Work Trials Teams

Shipbuilding and Ship Repair Yard Design & Production Technology

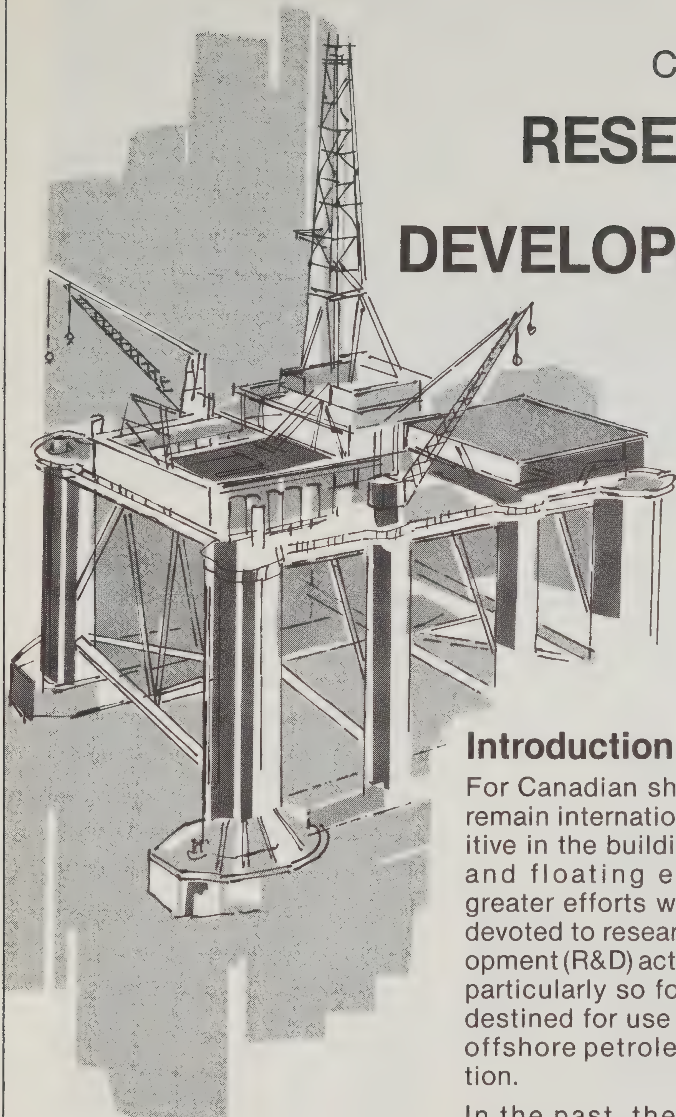
Shipyard Organization and Operating Systems

Training Systems/Programs

The principal people involved in this work are from the professional fields of Naval Architecture, Marine Engineering, Electrical and Electronic Engineering, assisted as necessary by technologists and craftspeople in these specialties.

CHAPTER 6

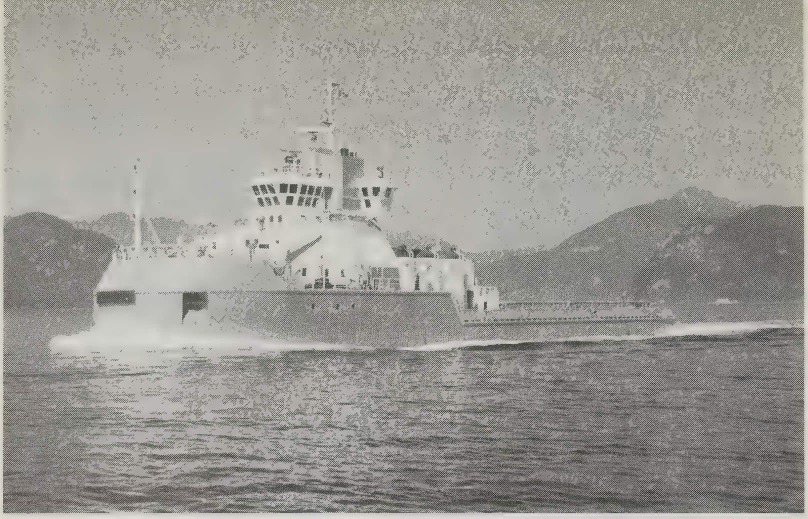
RESEARCH AND DEVELOPMENT



Introduction

For Canadian shipbuilders to remain internationally competitive in the building of vessels and floating equipments, greater efforts will have to be devoted to research and development (R&D) activities. This is particularly so for those units destined for use in Arctic and offshore petroleum exploitation.

In the past, the main effort devoted to R&D in the Canadian shipbuilding industry has been involved with solving specific problems such as the development of a new ship type or in development of special features such as acoustic silencing. Other developments have resulted in modernization and expansion of shipyards, and in the introduction of advanced equipments and machinery.



Icebreaking Arctic Class 3 Supply Vessel

New Initiatives

Over the last few years the marine community in Canada has been developing a strong interest in higher levels of technological innovation. While considerable work by both industry and government has been done to this end, a need has been identified for better integration of government, university and industrial research, particularly to overcome the frontier development challenges which are faced by the shipbuilding industry. In this regard, the Marine Advisory Board was created in 1976 by Transport Canada to improve the coordination of R&D in Canada and to advise the Federal Government on priorities for its support of the industry.

Recently, a number of universities have introduced courses in the science of Naval Architecture, Marine Engineering, Shipbuilding and Ocean Engineering. Technical and professional associations have organized forums for the exchange of information, and private and public companies have formed their own groups, such as the Arctic Petroleum Operators Association, for mutual assistance and to share the cost of research projects.

Many Federal Government departments are involved in R&D in marine technology. Environment Canada and Fisheries & Oceans pursue a variety of scientific and technical programs into ice mechanical properties and flow characteristics. The Canadian Coast Guard has an interest in marine technological development in support of its provision of services for navigation, safety and icebreaking, and to ensure that its regulations reflect the current state of the art. The Department of Regional Economic and Industrial Expansion and the Transportation Development Centre of Transport Canada are concerned with the degree to which marine R&D and new Canadian marine technology can meet objectives related both to the health of Canadian marine industry, and to the economic and social benefit of Canada's marine

Canadian Coast Guard Icebreaker
Courtesy of Transport Canada

equipment industry. National Defence and the National Research Council are also directly concerned with activity in marine R&D, while, Energy, Mines and Resources and Indian and Northern Affairs are vitally concerned with the degree do which marine technology will be available to meet the demands for new services required for the development of Arctic resources.

These Federal departments collectively have numerous research and applied development centres which require professional and technical staff.

Centres of Excellence in R&D in marine technology to support industry have been created by the Federal government in association with universities or with Provincial Research Associations. These are described below. In addition, many private companies, Provincial governments and agencies and not least of all consultants are contributing to advance the state of the art.

Use of marine railway to lift vessel out of the water

National Research Council Canada, Marine Dynamics and Ship Laboratory

With more than 30 years in marine research and development, the Marine Dynamics and Ship Laboratory of the National Research Council of Canada (NRC) and its staff have built a solid and growing international reputation. The laboratory has a long history of successful cooperation with government and industry on both large and small projects.

Expert knowledge and services are available in the following areas:

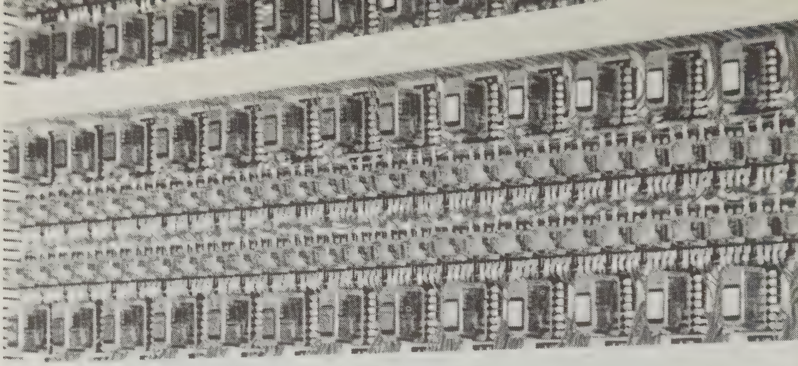
- Propeller hydromechanics and preliminary ship overall design;
- Ocean waves, response motions and seakeeping qualities of ships and ocean platforms;
- Computer calculations, computer and instrumentation systems for laboratory and ship use;
- Full-scale speed, power, manoeuvring and sea keeping trials;
- Calculations of full-scale trials for Arctic vessels. Self-propelled model tests in artificial ice;
- Yacht model testing.

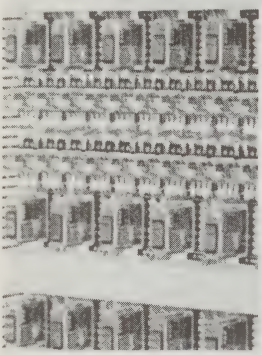
Main installations in the laboratory include a towing tank 137 x 7.6 x 3 m (450 x 25 x 10 ft.); a manoeuvring tank 122 x 61 x 3.7 m (400 x 200 x 12 ft.); artificial ice tank 43 x 6.1 x 1.4 m (140 x 20 x 4.5 ft.); a cavitation tunnel with a working section 2.5 x 0.5 x 0.5 m (8.2 x 1.6 x 1.6 ft.); advanced computer equipment and instrument systems.

The models used are typically from 2.5 to 6 m (8.2 to 19.6 ft.) in length, depending on the type of vessel, and satisfy the minimum size requirements for self-propulsion tests without undue wall or blockage effects. Models are cut and lines drawn automatically. A unique computer "elastic batten" technique is used to define the ship's surface while ship frames can be defined and automatically drawn from computer-stored data.

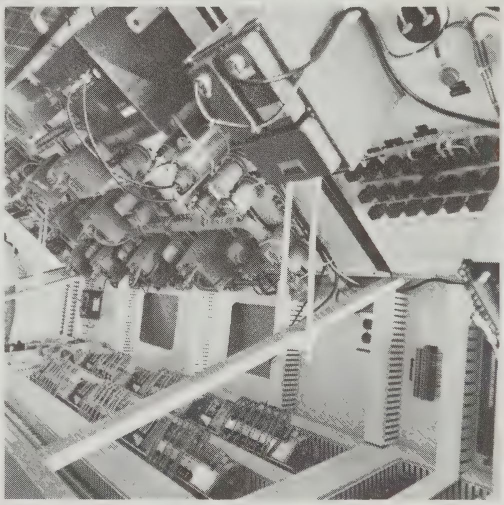
An associated NRC research group has been working on the physics and formation behavior of ice. This activity is centred on Strathcona Sound at the northern tip of Baffin Island.

Semi-submersible Oil Rig





Internal components of the console of the pre-programmed self-unloading system of a Bulker



Canadian Marine Research and Development Organizations (Associated with Universities/ Provincial Research Associations)

CENTRE OF EXCELLENCE FOR ICE COVERED WATERS, ST. JOHN'S

The Centre of Excellence is associated with Memorial University, and consists of:

- The Centre for Cold Ocean Resources Engineering (C-CORE)
- The Arctic Vessel and Marine Institute (currently under construction)
- The Department of Engineering and Applied Science
- Newfoundland Oceans Research and Development Corporation (NORDCO).

Basically, this group and associated consultants are concerned with the interaction of vessels and ice frequented waters.

Centre for Cold Ocean Resources Engineering (C-CORE)

Within the Memorial University structure, a highly specialized organization has been established at this Centre, backed by the facilities and personnel of the Faculty of Engineering and Applied Science.

Long Term Objectives:

- To help develop engineers and scientists competent to work with the cold ocean environment.
- To identify impediments to northern offshore resource development and to contribute to removing them and to interest others in the challenge and timely solution of such problems
- To stimulate the timely publication of the results of cold ocean engineering research.
- To contribute to the development of Newfoundland and Labrador as a centre for cold ocean engineering.

C-Core research programs include: radar souding of icebergs; study of the mechanical and engineering properties of sea ice; remote estimation of the physical properties of sea ice using impulse radar; evaluation of ice modelling techniques; and surveys of iceberg scouring in the Labrador Sea. Contract research has included studies of the Kurdistan oil spill and oil-ice interaction, of microwave systems to detect oil slicks over ice, of detection of oil under the ice, satellite ocean-related imagery applications, and ice strain on drilling platforms.

The Arctic Vessel and Marine Research Institute, Memorial University Campus

Costing $46.8 million and due for completion in 1983, this National Research Council Institute will contain an 80 metre towing tank for experiments under Arctic salt-water conditions as well as a 200 metre clear water tank for investigation of hydrodynamic forces on model structures. In addition, 75 metre tank will be used to study wave action on ships and other models.

Priorities will be applied to modes of marine operation in ice covered waters such as Transportation (bulk LNG, etc.); Fisheries (hull strength, fishing under ice, etc.); Mineral and Energy Exploration; Patrol Defence; Pollution Monitoring; Navigational Assistance, Mooring, Towing and Pushing; Ice Modelling; Fundamental Ice Problems; Manoeuvring and Course Stability; and Ice Friction Flow.

In summary, the Institute will be concerned with the development of new theory and applied research on vessel functions in real situations.

Memorial University

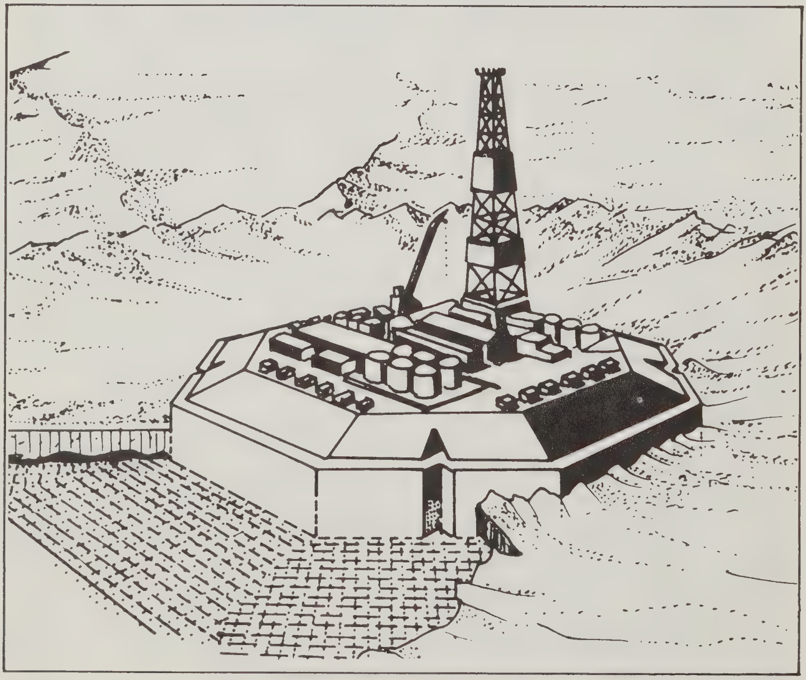
The major areas of interest lie with the Ocean Engineering Group and the undergraduate training in Shipbuilding Engineering. Ocean Engineering is concerned to a large extent with the movement and effects of icebergs, though their interests extend into other ice–vessel interaction.

Newfoundland Oceans Research and Development Corporation (NORDCO Limited)

NORDCO specializes in the research and development of technology related to the Arctic and other cold water environments. NORDCO is concerned primarily with: carrying out commercial research for private firms and government; the accumulation of information related to ice and the cold water environments; the extension of such knowledge through research and field studies; and the development of new or improved technology which will permit the efficient exploitation of the natural resources in such environments.

NORDCO has been active in iceberg drift modelling studies; Arctic harbour ice management studies; design of vessel modifications for a 1976 Labrador Sea Survey; fishing vessel design; sonar profiling icebergs; testing and installation of wave measurement system; iceberg tracking via satellite; shorefast ice experiments; oil slick surface drift modelling, oil-in-ice studies; icebreaker feasibility studies; LORAN-C Receiver evaluation; provision of weather information 24 hours per day to oil rigs in the Newfoundland-Labrador area; operation of the Shoe Cove Satellite Station; and dissemination of satellite imagery.

Caisson retained island



B.C. RESEARCH — OCEAN ENGINEERING CENTRE

B.C. Research

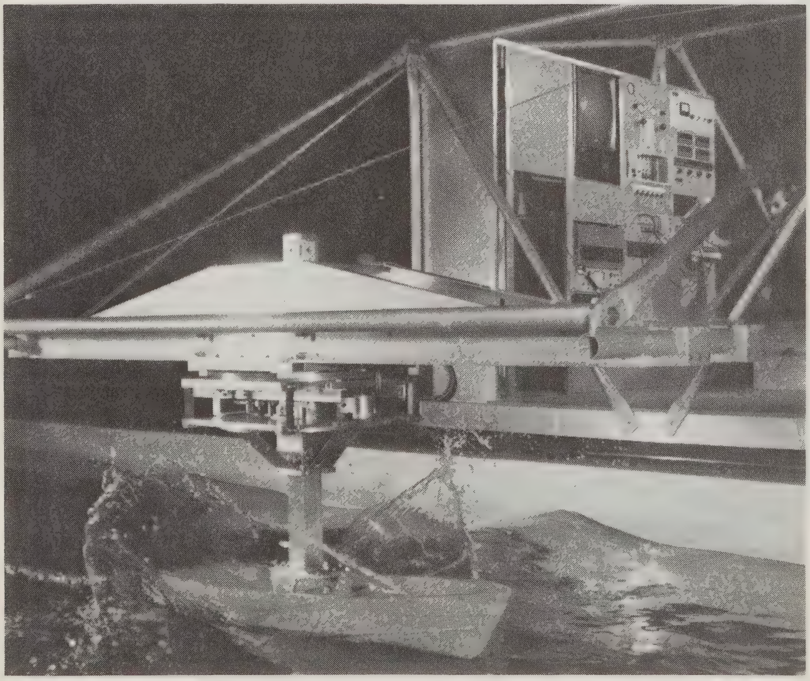
This organization conducts the technical operation of the non-profit, independent society, the British Columbia Research Council. It carries out research, development, and other technical work in the fields of Applied Biology, Applied Chemistry, Engineering, Physics, and Management Services under contract to sponsors both in industry and government.

Techwest Enterprises Ltd., is a subsidiary company, which moves research products, especially those of a hardware type, from B.C. Research to the marketplace.

Ocean Engineering Centre

This Centre located in the B.C. Research facilities, carries out ship model testing in its towing and manoeuvering tanks, produces ship models, offers design consultation on hull forms and structures, and designs electronic and hydraulic control systems. Research has been conducted on marine construction materials.

Ship model testing in towing/manoeuvering tanks



Other Organizations

The Classification Societies

The primary function of Classification Societies is to establish and maintain internationally recognized standards for the construction and maintenance of ships and to provide the technical services required by shipbuilders, designers and shipowners to assist them in meeting these standards. An important ingredient of these services is fulfillment of a responsibility to make available to local industry the Society's internationally acquired and continually up-dated technical knowledge and experience in order that local industry may benefit from worldwide technical developments. This also assures that regardless of where built, ships and their machinery are constructed and operated to the same internationally recognized and accepted standards.

Although governments are deeply involved in the application of regulations governing other aspects of ship design and operation such as personnel safety, crew requirements, navigation, pollution prevention, they do not attempt to set individual technical regulations for the design and construction of ships and their machinery. Instead, governments are guided by, and rely upon, the published Rules of approved classification Societies.

Classification Societies with exclusive Canadian surveyors resident in Canada are:

Lloyd's Register of Shipping (United Kingdom)

American Bureau of Shipping (United States)

Bureau Veritas (France)

Det Norske Veritas (Norway)

The surveyors are mainly professional and technical marine engineers and naval architects.

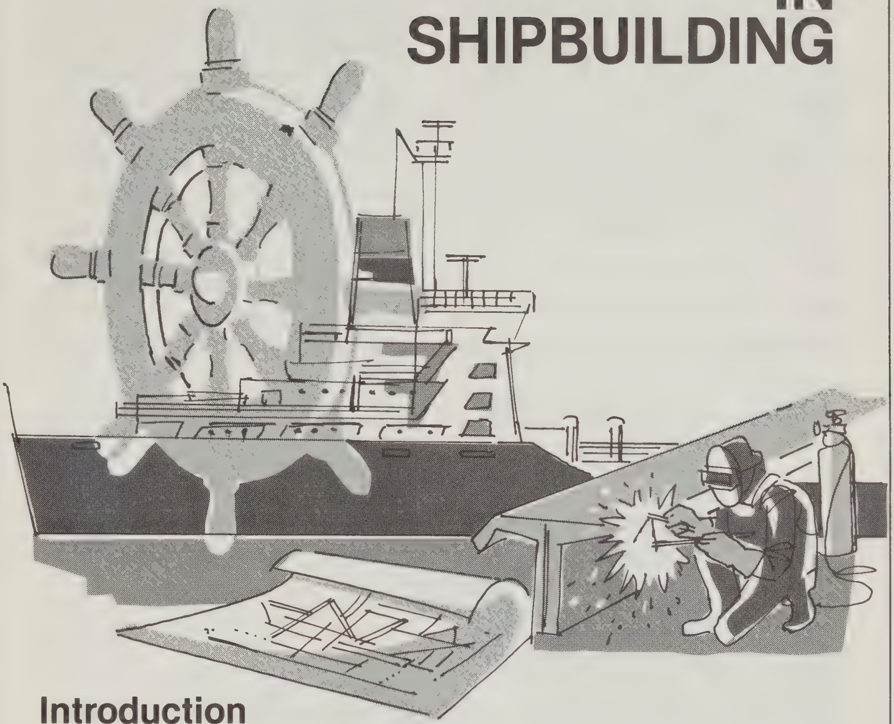
Welding in progress

The Welding Institute of Canada

This Institute undertakes research and development in welding and related fields to assist Canadian industries to improve their productivity and efficiency. In addition, the Institute provides training in operations, techniques, design, evaluation, production and other fields related to welding.

CHAPTER 7

CAREERS IN SHIPBUILDING



Introduction

A ship and many offshore floating units can be likened to a village or town in which people work, sleep, eat and relax — except that they can move over 70 percent of the earth's surface. The majority contain sleeping accommodation, eating facilities, kitchens, refrigeration, cold storage, laundry, bathrooms, toilets, common rooms and telephones. As in a town there is a fresh water system, sewage system, fire hydrant system, electrical power generation and transmission system and a heating/air conditioning system together with machine, repair and other shops, all enclosed in a steel shell. As well, many of the units contain propulsion plants, shafting, steering gear and associated machinery, navigational aids and other equipments. Hence, just as one would imagine in building a new town from scratch, many skills are also required in the building of a ship.

Because of the wide diversity of these skills, shipbuilding presents a rare combination of jobs and career opportunities. These are identified and outlined below.

University Graduates

Undergraduate Education

The shipbuilding industry needs university graduates from a number of disciplines. Amongst the more important are:

Naval Architecture

Shipbuilding Engineering

Ocean Engineering

Marine Engineering

Mechanical Engineering

Electrical/Electronic Engineering

In addition to the above, graduates in other disciplines are required in the fields of marketing, finance, purchasing, industrial relations, computer operations and training. These include:

Business Administration

Accountancy

Computer Science

Social Sciences

With the increasing complexity demanded for many new ships, coupled with the requirement for unique vessels and other large structures at the forefront of technology for use in the Arctic and iceberg infested offshore waters, the demand for highly qualified marine engineers, architects and others at the graduate or post-graduate level is increasing dramatically. This increased demand is likely to be sustained for years.

University courses leading to a graduate degree in the above noted disciplines are available from most universities in Canada with the exception of Naval Architecture and Marine, Shipbuilding and Ocean Engineering. The availability of programs in the latter four disciplines is given in the Table on Page 72.

Basic entry qualifications to a Canadian university is a good standing in Senior Matriculation or equivalent examinations.

On graduation and entry into the shipbuilding industry, the graduate would be given orientation training, although the extent of training would probably vary from shipyard to shipyard.

Post-Graduate Education

Due to the recent rapid advance in marine technological innovation together with that foreseen in the coming decades, positions will continue to be available for graduates with higher degrees, namely Master of Science (MSc) and Doctor of Philosophy (PhD).

These higher degrees can be taken by graduates immediately after their first degree or after some years in the work force. As an example, a graduate in mechanical engineering may wish to take a MSc degree in shipbuilding or in naval architecture which would be most useful to the individual and to a shipbuilder.

Technical or Technology College Graduates

In addition to the emerging requirement for university graduates in the shipbuilding industry there are continuing and parallel opportunities available for graduates of the Colleges of Technology.

In recent years, specific programs have been established in Colleges and Technical Institutes which provide education specifically oriented to the requirements of the shipbuilding industry and prepare the successful graduate for immediate contributions on the technical staffs of shipyards, engineering consultant firms, regulatory agencies, and associated industries.

Diploma of Technology level education is available in the colleges for the following important disciplines:

Naval Architecture

Marine Engineering

Electrical Engineering

Mechanical Engineering

Colleges offering such training are listed on pages 74 and 75 of this booklet.

A painter at work

Skilled Tradespeople

As the complexity of new vessels and large structures increases and advanced marine technology innovations are introduced, so the need increases for capable people to take up responsible positions throughout the industry.

The majority of entrants into the shipbuilding trades in Canada would receive training when joining. This may take one of the following forms:

a) **Training to Journeyman/woman Level** — which is defined as at least 2-3 years of training and experience to ensure effective performance.

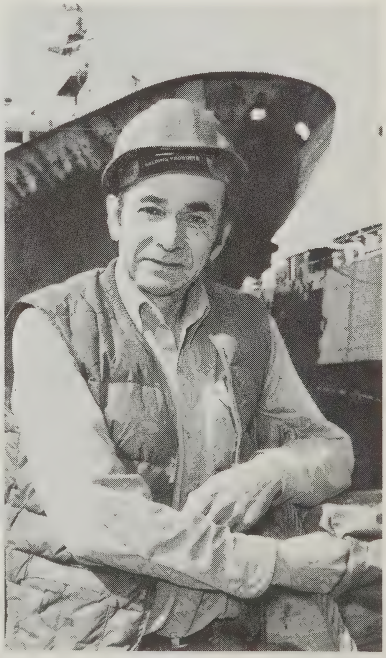
b) **Apprentice Training** — which is defined as industrial education of not less than a minimum of 52 weeks and subject to the attainment of a satisfactory standard job capability in a skilled trade; and/or training which generally requires the worker to be registered in a Provincial training scheme.

c) **Developmental Training** — which is training conducted formally or on-the-job to advance or augment the existing skills or knowledge of a worker.

The Skilled Trades

Some of the more important skilled trades in the Canadian shipbuilding industry are:

Platers
Burners
Welders
Loftpersons/Programmers
Shipwrights
Engine Fitters/Machinists
Electricians
Pipe Fitters
Carpenters/Joiners
Sheet Metal Workers
Painters
Riggers/Slingers
Draftspersons
Crane Operators



Assistant foreman

Minimum Level of Education for Entry

Although no minimum national educational standard is laid down in Canada for admittance to the training schemes leading to entry into the skilled trades in the shipbuilding industry, the Canadian Shipbuilding and Ship Repairing Association and its members have identified guidelines for entry.

In essence, these guidelines indicate that prospective entrants should be at least a graduate of a Technical High School or a Community College/CEGEP, or alternatively have a Junior or Senior Matriculation Certificate. Ideally, the best time for a prospective apprentice to start an apprenticeship is after completion of secondary school at the age of 18 years, by which time the entrant should have mastered the English or French language, or both, the basics of mathematics and learned how to reason and apply knowledge.

Safety and Training instructor showing the burning table installed for apprentice training

Training

Each Canadian Province and Territory has the responsibility for setting occupational qualifications and for the training and certification of tradespeople. Because trades developed to meet the needs of different geographical regions, a variety of provincial certification standards exist within the trades across Canada.

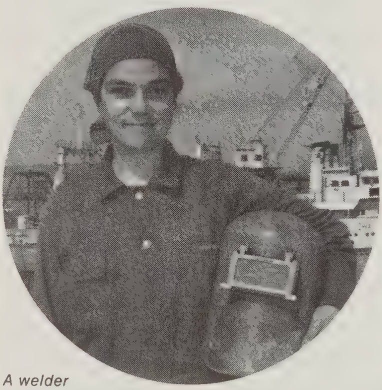
To overcome this lack of uniformity, an Interprovincial Standards Examination Program (Red Seal) was introduced in 1958. Its purpose is to establish uniform apprenticeship trade standards and examinations. There is a continuing process to add to the number of "Red Seal" trades which now number twenty-five.

The Canadian Shipbuilding and Ship Repairing Association and its members have agreed to promote this program in the shipbuilding trades and work to this end is now in progress.

At this time the training of an apprentice to the journeyman/woman level takes 3-4 years with 20-25 percent of the time devoted to classroom training. The shipyards favour training apprentices in their shipyard schools but Provincial Trade and Vocational Schools, Night Schools and Community Colleges/CEGEP across the country also offer training, which in some instances is used by specific shipyards for their apprentices.

In addition, Development Training is carried out in the shipyards to advance or augment the existing skills or knowledge of a worker.

Many shipbuilders employ training supervisors who coordinate and control the training programs. Encouragement is given to the trainees and to other interested workers to follow a course of further education or training by Developmental Training within the company, by giving time off with pay to attend courses or by financial reimbursement for night school. Successful completion of these various courses is recognized by Certificates, Provincial or Red Seal Certificates and Diplomas.



A welder

Career Opportunities and Positions in the Industry

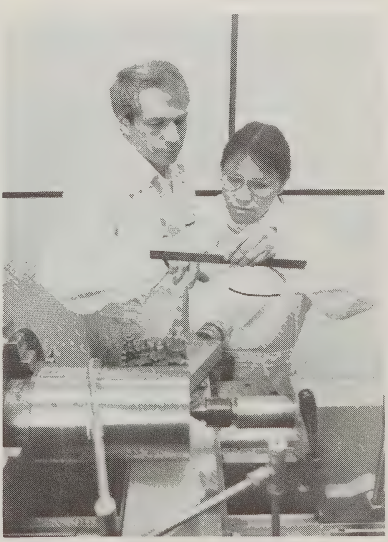
Opportunities abound in the shipbuilding industry for new graduates, who with experience and through personal development and perhaps further education can progressively move up the hierarchy of a firm to positions of the highest responsibility. Keenness, dedication and loyalty are key ingredients for success.

Opportunities are also available for capable journeymen/women to move into management or supervisory positions of responsibility, taking charge of workers, machines and equipment. The development of supervisory and management skills within the workforce is an essential factor to the well-being of a shipyard and to the industry as a whole. To those who respond and who are technically competent and show the required aptitude, opportunity will beckon.

Sheet metal worker and a welder

Some positions within the Canadian shipbuilding industry are:

General Manager
Manager — Engineering
Manager — Ship Repair
Chief Engineer
Naval Architect
Marine Surveyor
Manager — Production
Shipyard Manager
Production Engineer
Planning Engineer
Safety Engineer
Quality Control Engineer
Plant Engineer
Fabrication Manager
Erection Manager
Director of Personnel
Industrial Relations Manager
Director of Finance
Computer Manager
Accountant
Purchasing Manager
Marketing Manager
Materials Manager
Training Manager
Chief Draftsman/woman
Occupational Health Officer
Industrial Hygiene Officer
Foremen/women
Workshop Supervisors
Section Leaders
Platers
Burners
Welders
Loftpersons/Programmers
Shipwrights
Engine Fitters/Machinists
Electricians
Pipe Fitters
Carpenters/Joiners
Sheet Metal Workers
Painters
Riggers/Slingers
Draftsmen/women
Crane Operators
Secretaries
Clerks
Labourers



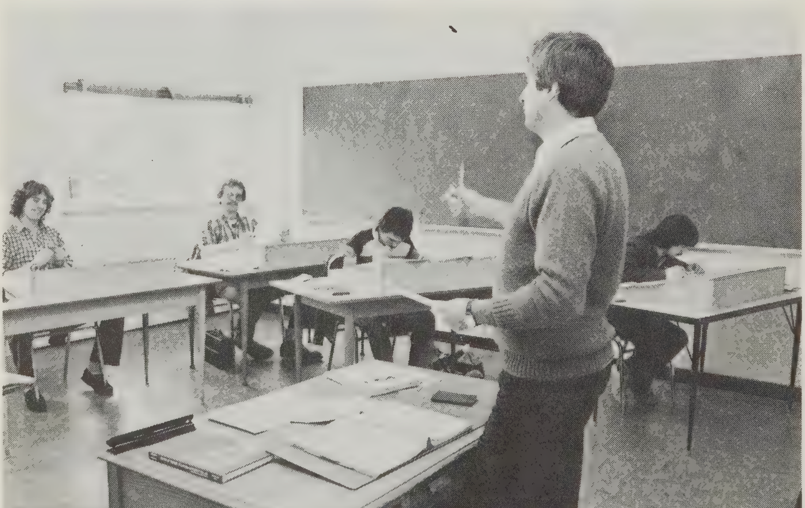
Machining operations

Other Career Opportunities

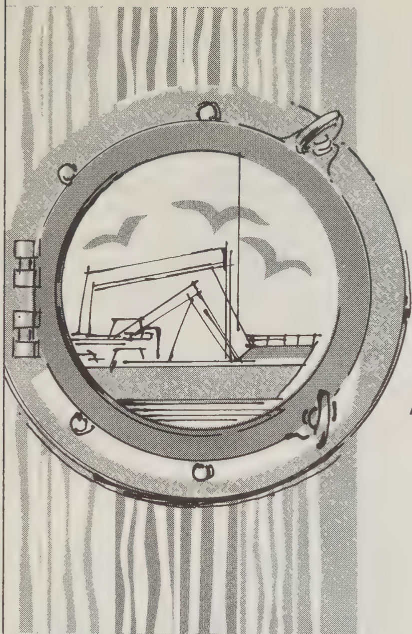
Associated with and/or assisting and supporting the shipbuilding industry are many other organizational entities such as the steel, machinery and equipment manufacturing industries, research and development organizations, government, consultants, shipowners including some oil and gas companies, and educational institutions. These employ not only university graduates but all levels of skilled and trained people, with the demand exceeding the supply for well qualified, experienced shipbuilding industry personnel. Should marine engineers or naval architects for instance, decide to leave the shipbuilding industry after holding a position of responsibility for some time, they should have little difficulty finding challenging employment elsewhere in their chosen field.

Similarly, should skilled tradespeople decide to leave the industry, after a reasonable period in a responsible job, they should experience little difficulty in finding rewarding employment elsewhere — as the demand for highly skilled persons also exceeds the supply. This also holds true for those with skills such as clerical, supply, data processing and others needed in shipbuilding and in other industries.

It is a well known fact that there is a critical shortage of well qualified and experienced engineers, technologists and skilled tradespeople within the marine industries in Canada today. This is likely to persist for years, being exacerbated by the expanding exploration and exploitation of natural resources in the Arctic and offshore.



Classroom instruction for apprentices



CHAPTER 8

CANADIAN INSTITUTIONS INVOLVED IN MARINE EDUCATION AND TRAINING

Introduction

In the early 1970's, growing concern of the aging workforce in the marine sector coupled with the general lack of adequate training facilities brought about the establishment of a National Advisory Council on Marine Training (NACMT) by the Federal Government. Together with the Provinces of British Columbia, Ontario, Quebec, Nova Scotia, New Brunswick, Prince Edward Island and Newfoundland, and with the support from industry and labour new training facilities have been built and older ones enlarged and upgraded. Numerous new programs have been introduced and existing ones rewritten and expanded. As many of these Provincial programs meet a common standard, progressive expansion of uniform certification standards across Canada is being achieved.

Adding impetus to this expansion and improvement in marine training is the urgent need for highly qualified and experienced marine engineers, naval architects, technologists and skilled tradespeople in the shipbuilding and supporting industries and in the petroleum, shipping, fishing and other industries, to meet their growing needs. With the increasing activity in the exploitation of natural resources in Arctic and offshore waters, the demand for trained and experienced personnel will progressively increase, dictating further expansion of training facilities.

Degree Courses

Most universities in Canada offer degree courses in mechanical and electrical/electronic engineering. The following universities, however, offer marine oriented courses as follows:

Current Level	**Technical University of Nova Scotia Halifax, N.S.**	**Memorial University of Newfoundland St. Johns, Nfld. A1C 5S7**	**University of British Columbia 2075 Westbrook Pl. Vancouver, B.C. V6T 7W5**
Bachelor	Marine Engineering Naval Architecture	Shipbuilding Engineering (Naval Architecture) Ocean Research	Naval Architecture Options in Mechanical Engineering Oceanography (being proposed)
Master		Ocean Engineering	Oceanography
Doctorate		Ocean Engineering	Oceanography

Current Level	**McGill University 762 Sherbrooke St. West Montreal, Que. H3A 1G1**	**Dalhousie University University Ave. Halifax, N.S. B3H 2A1**	**Université du Québec à Rimouski 300, av. des Ursulines Rimouski G5L 3A1**
Bachelor	Oceanography	Oceanography	Oceanography
Master	Oceanography	Oceanography	Oceanography
Doctorate	Oceanography	Oceanography	——

The main university and college courses currently available in Canada are outlined below. Not included are the programs offered by the Canadian Military Colleges which include a Bachelor degree course in "Physics and Oceanography" at the Royal Roads Military College in Victoria, B.C., and Bachelor and Master degree programs in Mechanical and Electrical Engineering at the Royal Military College in Kingston, Ontario. Similarly, the three year engineering training program at the Canadian Coast Guard College in Sydney, N.S., the marine engineering programs offered by the Transport Canada Training Institute in Cornwall, Ontario, the National Defence marine training programs including apprentice training in the Ship Repair Units in Esquimalt, B.C. and Halifax, N.S., and the Seafarers Training Institute at Morrisburg, Ontario, are not included.

An apprentice receiving instruction

Practical training in a machine shop

Trainees undergoing drawing instruction

Diploma and Certificate Courses

The following Community Colleges and CEGEP offer courses in Marine Engineering, Electrical Engineering, Mechanical Engineering, Naval Architecture and Shipbuilding:

a) Marine Engineering Technology

	Course Length
College of Fisheries, Navigation, Marine Engineering and Electronics P.O. Box 4920 St. John's Newfoundland A1C 5R3 (709) 892-4191	3 Years
Nova Scotia Nautical Institute P.O. Box 578 Halifax, Nova Scotia B3J 2S9 (902) 424-3290 (**Note:** Programs are being expanded to include a 3 year program)	1 Year
Institut maritime du Québec 53 ouest, rue Ste-Germaine, Rimouski, Québec G5L 4B4 (418) 724-2822	3 Years
St. Lawrence College Windmill Point Cornwall, Ontario K6G 4Z1 (613) 933-6080	3 Years
Georgian College of Applied Arts and Technology 1150 – 8th Street, East Owen Sound, Ontario N4K 5R4 (519) 376-0682	3 Years
Niagara College of Applied Arts and Technology St. Catharines Campus Woodlawn Road Welland, Ontario L3B 5S2 (416) 684-4315	3 Years
Pacific Marine Training Institute 265 West Esplanade North Vancouver, British Columbia V7M 1A5 (604) 985-0622	3 Years

b) Naval Architecture and Shipbuilding Technology (DIPLOMA)	Course Length
College of Fisheries, Navigation, Marine Engineering and Electronics (See a) above for address)	3 Years
Institut maritime du Québec Rimouski (See a) above for address)	3 Years

c) Engineering Certificate in Naval Architecture Technology

British Columbia Institute of Technology 3700 Willingdon Avenue Burnaby, British Columbia V5G 3H2 (604) 434-5734	Part-time — 6 hrs./week for 3 Years

d) Small Craft Design (Certificate)

College of Fisheries, Navigation, Marine Engineering and Electronics (See a) above for address)	2 Years

e) Other Programs

College of Fisheries, Navigation, Marine Engineering and Electronics
(See a) above for address)

Industrial Instrumentation	2 Years
Marine Electronics	2 Years
Marine Electrical Practice	1 Year
Marine Steelwork	9 Months
Marine Diesel	9 Months

In addition, there are numerous other colleges, institutions and schools in the provinces outlined above which give training in marine engineering at various levels. As well, all seven provinces offer specialized marine engineering upgrading programs to assist those seeking certification at higher levels.

Appendix 1

For Further Information

Additional information on Provincial institutions conducting marine technical education and training, can be obtained from the Department of Education of the applicable province.

Should further information be desired the Career Counsellors at Universities, Colleges and Schools and/or the Counsellors at the Canada Employment Centres across Canada should be consulted.

For specific information on recognition of a Provincial or Territorial apprenticeship certificate and on the requirements for Provincial registration if wishing to work in a Province other that the one which issued the certificate, contact the applicable office listed below:

Newfoundland

Director
Apprenticeship Branch
Department of Labour
Manpower
Confederation Building
St. John's, Newfoundland
A1C 5T7

New Brunswick

Director
Industrial Training and
Certification Branch
Department of Labour
and Manpower
P.O. Box 6000
Fredericton, New Brunswick
E3B 5H1

Prince Edward Island

Director
Apprentice Branch
Department of Labour
Box 2000
Charlottetown, P.E.I.
C1A 7N8

Nova Scotia

Director
Apprenticeship and
Trademen's Qualification
Branch
Department of Labour
and Manpower
P.O. Box 697
Halifax, Nova Scotia
B3J 2T8

Québec

Direction générale des
politiques et programmes
Secteur formation
professionnelle
Ministère du Travail, de la
Main d'oeuvre et de la
Sécurité du revenu
3e étage, 255 boul. Crémazie
est
Montréal, Québec H2M 1L5

Ontario

Director
Skills Development Division
Ministry of Colleges and
Universities
Mowat Block – 16th Floor
900 Bay Street
Toronto, Ontario
M7A 2B5

Manitoba

Director
Apprenticeship and
Tradesmen's Qualification
Branch
Department of Labour
and Manpower
600 Norquay Building
401 York Avenue
Winnipeg, Manitoba
R3C 0V8

Saskatchewan

Director
Apprenticeship and Standards Division
Department of Labour
1914 Hamilton Street
Regina, Saskatchewan
S4P 4V4

Alberta

Director
Apprenticeship and Trades Certification Branch
Department of Advanced Education and Manpower
5th Floor, Devonian Bldg. – East Tower
11160 Jasper Avenue
Edmonton, Alberta
T5K 0L1

British Columbia

Director
Apprenticeship Training Programs Branch
Ministry of Labour
4946 Canada Way
Burnaby, B.C.
V5G 1M1

Yukon Territory

Director
Adult and Continuing Education
Department of Education
Government of the Yukon Territory
Box 2703
Whitehorse, Yukon Territory
Y1A 2C6

Northwest Territories

Chief
Manpower Development Division
Department of Economic Development and Tourism
Government of N.W.T.
Yellowknife, N.W.T.
X1A 2L9

Federal Government

Employment & Immigration Canada

Director General
Manpower Training
Employment and Immigration Canada
Ottawa, Ontario
K1A 0J9

National Defence

Director of Recruiting & Selection
National Defence Headquarters
Ottawa, Ontario
K1A 0K2

Transport Canada

The Director
Canadian Coast Guard College
P.O. Box 4500
Sydney, Nova Scotia
B1P 6L1

The Director
Training Priorities & Systems
Transport Canada
Place de Ville
Ottawa
K1A 0N5

Appendix 2

Acknowledgements

The Canadian Shipbuilding and Ship Repairing Association is grateful to all who have assisted in the preparation of this booklet by provision of information, photographs and/or advice. They include:

- *Members of the Canadian Shipbuilding and Ship Repairing Association including in particular A&P Appledore Canada Ltd. who provided the information on a Ship Production Control System.
- Dome Petroleum Limited, Calgary, Alberta
- Algoma Central Railway, Sault Ste. Marie, Ontario
- National Advisory Council on Marine Training, Canadian Coast Guard, Transport Canada, Ottawa, Ontario
- Employment and Immigration Canada, Ottawa, Ontario
- Memorial University of Newfoundland, St. John's, Newfoundland
- Technical University of Nova Scotia, Halifax, Nova Scotia
- University of British Columbia, Vancouver, British Columbia
- Nova Scotia Nautical Institute, Halifax, Nova Scotia
- Dalhousie University, Halifax, Nova Scotia
- Nova Scotia Department of Fisheries, Halifax, Nova Scotia
- Université du Québec à Rimouski, Rimouski, Québec
- Institut maritime du Québec, Rimouski, Québec
- Institut des Pêches du Québec, Grande-Rivière, Québec
- St. Lawrence College, Cornwall, Ontario
- Georgian College of Applied Arts and Technology, Owen Sound, Ontario
- Niagara College of Applied Arts and Technology, Welland, Ontario
- Pacific Marine Training Institute, North Vancouver, British Columbia
- Seaspan International Ltd., North Vancouver, British Columbia
- British Columbia Institute of Technology, Burnaby, British Columbia
- Transport Canada, Ottawa, Ontario
- C.N. Marine, Moncton, New Brunswick
- Department of National Defence, Ottawa, Ontario
- Cominco Limited, Vancouver, British Columbia

*Members of the CSSRA are listed on the following page.

Full Members

Allied Shipbuilders Limited
Bel-Aire Shipyard Limited
Burrard Yarrows Corporation —Vancouver & Victoria Divisions
Collingwood Shipyards
Davie Shipbuilding Limited
Ferguson Industries Limited
Halifax Industries Limited
Marine Industries Limited
Marystown Shipyard Limited
Newfoundland Dockyard
Port Arthur Shipbuilding
Port Weller Dry Docks
Rivtow Industries Limited
Saint John Shipbuilding & Dry Dock Co., Ltd.
Vancouver Shipyards Co., Limited
Versatile Vickers Inc.

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Georgetown Shipyard Inc.
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Computing Devices Company
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Wagner Engineering Ltd.
Westinghouse Canada Inc.
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